# dimmPCI™ 68VZ328 Hardware / Software Manual

www.amctechcorp.com

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## Contact Information

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## dimmPCI™ Software Development Kit

# NETdimm Developers Kit Quick Start Guide

This document is provided to help users bring up the NETdimm Developers Kit hardware and software as quickly as possible. If difficulties are encountered using this guide please refer to the complete instruction manual.

1. Find a static-free work area to use and remove the **dimmPCI Developers Backplane**, **NETdimm, IOdimm** and **POWERdimm** from their static protective bags.
2. Insert the **NETdimm** module into the **System Slot** (see figure below) on the **backplane**, the one closest to the screw terminal connectors. Insert the **POWERdimm** into the slot opposite the **NETdimm.** Ensure the modules are fully seated and the side tabs are snapped closed and that the modules are in the proper slots.
3. Warning: Placing the modules in the incorrect slot may result in damage to the modules. Please verify that the modules are in the correct slot before continuing. The POWERdimm must be placed in the power slot (expansion slot 3) and the IOdimm (if used) must be placed in expansion slot 2. The NETdimm can be placed in either the system slot or expansion slot 2.
4. Connect the Serial Adapter Cable (**DB9 on one end, 10 pin header on the other)** to the **backplane** connector **JP5**; the red strip on the cable should match up to the dot on the backplane next to the connector. These both denote pin number 1.
5. Use the supplied **serial cable** to connect the Serial Adapter Cable to the **development computer**. Please note which serial port the cable is connected to (ie. COM1 or COM2) **Note:** the development computer must be running Linux to be able to use the development tools supplied.
6. CAUTION: Failure to follow the following instructions may result in damage to the NETdimm module or backplane. Jumper **pins 7** and **8** together on **JP7**, the power jumper to supply the **POWERdimm** with power. Ensure that the wall adapter is **NOT** plugged in and connect the **negative** wire of the adapter to **GND** on the power connector and the **positive** wire of the adapter to **VIN** on the power connector. Do not plug in the wall adapter at this time.
7. At this point the hardware is properly configured and it is time to install the development tools. Insert the **dimmPCI SDK** CDROM into the computer and mount it on the filesystem.
8. From the root of the CDROM type **make install** to install the development tools to the

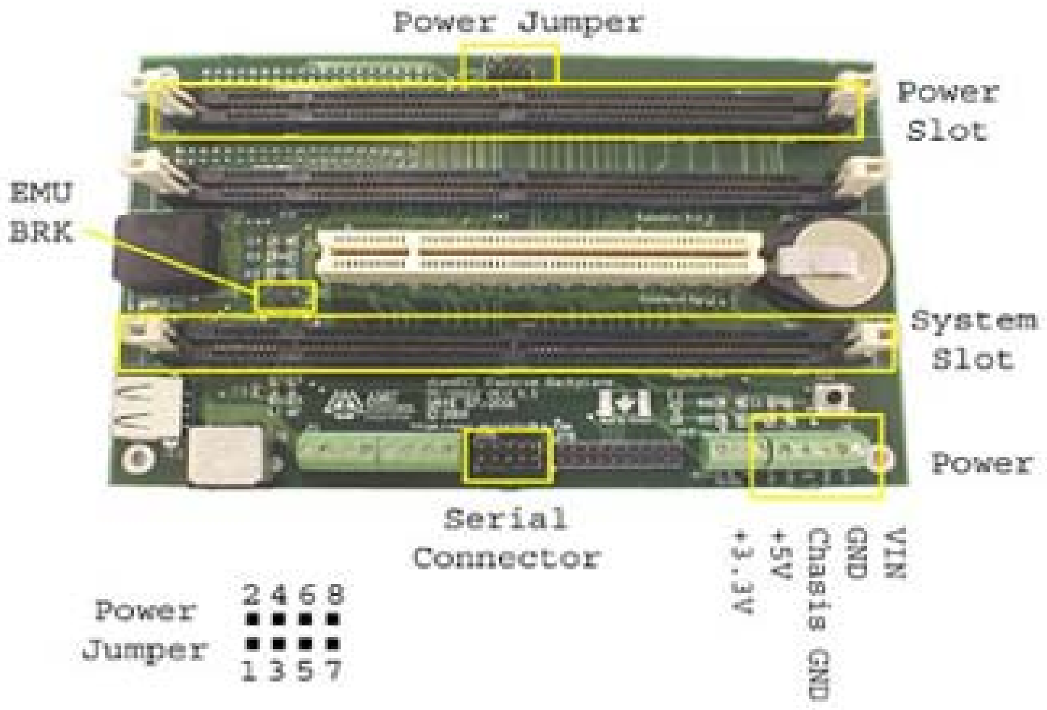
computer.

9. Ensure the **EMU BRK** jumper is not installed.
10. Open the Linux "**minicom"** application. Select the serial port attached to the development kit and configure the port for 115.2 kbps and 8N1 serial protocol. Power up the **wall adapter**. The terminal window will act as the controlling console for the **NETdimm**.
11. After booting up, the console will display a login prompt, as is shown below

```
  /etc/issue              www.dimmpci.com                2 April
  2002



      Welcome to AMCTC's dimmPCI running uClinux!



        See the following web sites for more information:

      www.dimmpci.com: information specific to the dimmPCI platform
      www.uclinux.org: information and tools for generic uClinux


dimmPCI login:
```

12. Enter the username **root** and the password is blank, just press enter.

That's it; the development kit will act like a normal linux system now and is ready to be used to develop powerful new embedded applications.


Power Jumper
Power Slot
EMU BRK
System Slot
Power
Serial Connector
VIN
GND
Chasis GND
+5V
+3.3V
Power Jumper
2 4 6 8
1 3 5 7

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# 1 Introduction

## Launching Linux at the embedded

The modern world runs on computers and technology. Every corner you turn, every road you travel, computers are helping you get there. Embedded systems are the fuel in these computers and the lifeblood of modern-day electronics. So what is an embedded system? An embedded system is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function. In some cases, embedded systems are part of a larger system or product, as is the case of the joystick control system in the B2 Stealth Bomber.

Embedded systems come in different sizes and packages. There are systems that can fit on a dime and systems that won't fit in your closet. Each system has available to it a wide variety of computing power and a large diversity of functionality. These systems allow the technologically inclined the ability to control and perform repetitive tasks with more reliability and accuracy than any other methods previously used.

So how are these systems created? Engineers and firmware experts develop embedded systems. These specialists write thousands of lines of instructions and program these systems with the instructions using various software packages. These instructions can be written in C, assembler or any other variety of programming language. These languages are available under Linux, Windows and many other operating systems. When these systems are programmed, the instructions become embedded in the memory of the system, thus the embedded system is created.

Now the question is how can the designer program these systems in a way that is easy for the end user to operate and inexpensive for the designer to produce. The simple solution is to embed Linux.

Linux provides dependability, flexibility and scalability. Linux is a proven dependable architecture that several companies have grown to use and excel with. Linux's flexibility is proven in its ability to support a huge number of microprocessors, hardware devices, graphics devices and applications. Finally, the scalability of Linux is beneficial because it spans a wide range of computing functions. For example, mini web servers all the way up to large mainframe computing systems use Linux or Unix based structure.

Besides all of the impressive features of Linux, it is also openly available in several different arrangements and configurations. This diverse array of compatibility of Linux and its supporting software has evolved to the needs of the market and applications of which Linux is being adapted.

One of the most interesting qualities of embedded Linux is the abundance of architectures that it is compatible with. Linux has been ported to such architectures as x86, MIPS, and the PowerPC. So, how do you decide which architecture to use? That depends; in the dimmPCI$^{TM}$ we've chosen to take advantage of the Motorola 68VZ328 DragonBall architecture.

The one thing to recognize about a Linux system is that all versions are basically variations of the same idea. This means that all Linux systems are essentially compilations of the same basic components. These components can include the kernel, libraries, drivers, command shells, GUI, and utilities.

So what makes these distributions different? The differences can be found by examining the core of each Linux version. These versions can contain different utilities, modules, kernel patches, etc. These distributions are also differentiated in the way that they are installed, configured, maintained and upgraded.

The dimmPCI$^{TM}$ hardware introduces the user to the world of embedded Linux in a complete and efficient way that is easy for the user to comprehend. By supplying a finalized, component level solution that can be plugged into a DIMM socket to enable the user the functions described above almost anyone can be using and manipulating an embedded system. The dimmPCI$^{TM}$ along with the passive backplane can be the solution to your engineering system or it can simply be the add-on you need to complete your process. Either way, the dimmPCI$^{TM}$ will greatly reduce your engineering design costs and your time to market.

## What’s on the CD?

On the CD you will find:

- µClinux source files with patches to work on the dimmPCI™ platform.
- GCC cross compiler tools for the DragonBall processor, with the necessary library files included.
- Tools for use under µClinux on the target board, along with source code.
- A flash loader program, to reprogram the board with new image files.
- Sample applications to show the capabilities of the dimmPCI™ development kit.
- Application notes describing how to configure dimmPCI modules for communication, use an LCD with a NETdimm, setup dimmPCI modules for Digital I/O, use multiple NETdimms, and how to use Digital and Analog I/O with the IOdimm.

## System Requirements

The dimmPCI™ System Development Kit requires a Linux host computer to be the development workstation.

- 115200 bps serial port
- CD-ROM Drive
- 10Base-T ethernet (optional but recommended)
- x86 Linux machine (we support RedHat 7.0 and 7.1)
- Redhat Package Manager (RPM)
- GCC compiler tools

A working knowledge of the Linux operating system is highly recommended

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# 2 dimmPCI$^{TM}$

## uC68VZ328 Embedded Microcontroller

## Features

### CPU Module

- Powerful 33 MHz DragonBall microprocessor
- Up to 32 Mbytes SDRAM
- Up to 8 Mbytes Simultaneous Flash Memory
- Up to 1kbyte of serial EEPROM
- 168 pin DIMM form factor
- Less than 500 mW power dissipation
- Real Time Clock
- Dallas Watchdog Timer
- On board µClinux OS including TCP/IP
- 2 serial ports
- Proposed dimmPCI$^{TM}$ standard bus
- Proposed dimmSPI$^{TM}$ standard bus
- 33 MHz PCI performance
- 32 bit PCI data transfers
- Ethernet interface

### Backplane

- Graphical “PDA Style” LCD module interface
- USB ready
- Low cost PCI compatible devices
- Expandable and highly configurable
- Excellent price/performance ratio
- Ethernet interface
- Economical

## General Description

AMC Technologies Corporation (AMC) has developed the proposed dimmPCI™ standards specification which defines electrical signaling and mechanical specifications for a new generation of low cost Peripheral Component Interconnect (PCI) compatible devices. DimmPCI™ is an adaptation of the PCI Specification 2.1 for embedded applications. All dimmPCI™ cards are peripheral interface cards that install directly on a low cost backplane. The cards share the same physical size as the module described in the JEDEC Dual Inline Memory Module (DIMM) specification for a 168 pin DIMM module.

Due to the high volume, low cost nature of the connector, dimmPCI™ sets new price/performance milestones for embedded systems developers. The interface cards communicate using standard PCI bus signaling and are compliant with the 33Mhz, 32-bit PCI bus specification.

The dimmPCI™ technology is applicable when facing tight budgets and demanding technical requirements. In addition to the processor slot, up to four other dimmPCI™ slots are available for expansion cards. There are a large variety of expansion cards to select from including analog I/O, digital I/O and special communications functions. This highly configurable and economical platform allows users to develop custom solutions at commercial-off-the-shelf prices.

AMC provides engineering support for the dimmPCI™ technology and can assist in developing and supporting products that utilize this architecture. AMC has initiated the development of the proposed dimmPCI™ standard and can assist in adopting this technology in application specific areas. AMC also provides engineering support and manufacturing for other networked industrial control applications and product lines.

## CPU Module Description

The AMC Dragonball dimmPCI™ CPU module is a cost effective solution for technically demanding applications. This dimmPCI™ module is designed around the powerful and economical DragonBall VZ microprocessor.

The CPU module can contain up to 32 Mbytes of SDRAM, 8 Mbytes of flash and 1kbyte of EEPROM. Also included on the CPU module are a real time clock, a watchdog timer and 2 serial ports.

The Dragonball dimmPCI™ CPU module supports Ethernet 10BaseT, two serial ports, and a graphical "PDA style" LCD interface. The module conforms to the proposed dimmPCI™ standard and may be used with a complementary array of other modules on a dimmPCI™ backplane. These expansion cards include a COMM module that supports dual Ethernet 10/100BaseT channels and CAN communications, a DAIO module that supports digital and analog I/O, and a power supply module.

AMC provides engineering support for the Dragonball dimmPCI™ CPU module and can assist in developing and supporting hardware and software for specialized applications. This CPU module is programmable using the industry standard 'C' programming language and utilizes the very reliable Linux operating system. AMC has extensive experience in applying Linux to Internet appliance applications. AMC also provides engineering support and manufacturing for other industrial control applications and product lines.

The CPU module can be obtained with or without the PCI on board.

## Backplane Description

The AMC dimmPCI™ 3U Backplane forms a versatile foundation for cost-effective rapid application development for a wide variety of technically demanding applications. The backplane conforms to the proposed dimmPCI™ standard and may be used with a complementary array of dimmPCI™ modules. This economical platform allows users to develop custom solutions at commercial-off-the-shelf prices.

The dimmPCI™ 3U Backplane has four available slots for expansion modules. Of the four slots, three are dimmPCI™ slots and one is a standard 5V PCI slot. The dimmPCI™ slots support a variety of expansion cards. The modules include:

- A range of CPU modules with different microprocessor architectures and performance
- COMM modules that support Ethernet 10/100BaseT, CAN, DeviceNet, Modbus and other RS-232 and RS-485 based serial protocols
- DAIO modules that support digital and analog I/O
- A power supply module

The standard PCI slot supports any 3V or 5V 32-bit PCI expansion card.

The dimmPCI™ specification provides for user defined I/O signaling to each module. The dimmPCI™ 3U Backplane makes these readily available so application developers have a convenient way to access the I/O, reduce development costs and reduce time to market.

## Architecture

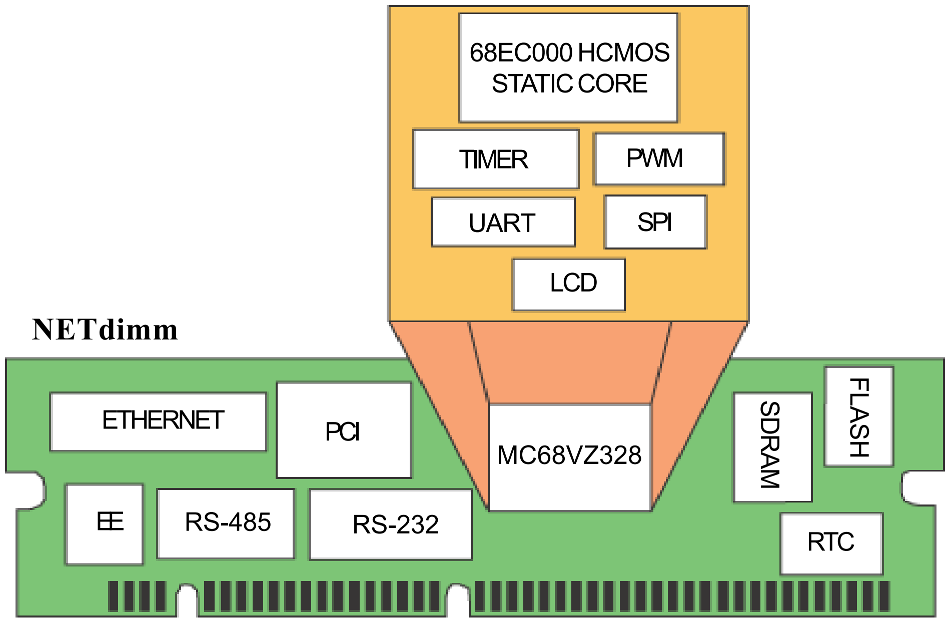


**Figure 1. CPU Architecture**

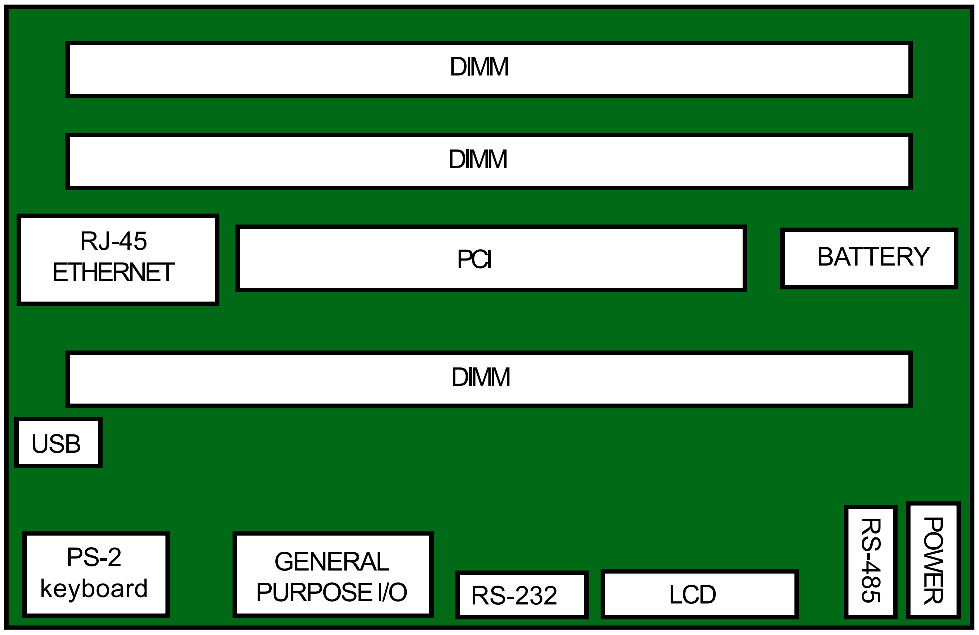


**Figure 2. Backplane Architecture**

The CPU Architecture consists of 4 main functional regions. The Ethernet Controller, the PCI Interface, the MCU Core and System Memory. These regions form a highly integrated embedded system. The Backplane Architecture consists of 3 main regions. The Communication Connectors, the DIMM and PCI Slots and the LCD Connector. These regions complete the dimmPCI™ system.

## The MCU Core

The MC68VZ328 provides system designers more performance with the capability of running at higher speed while achieving lower power consumption with a true static core. The MCU features a fully static synthesizable FLX68000 Core Processor. This processor provides more than 5 MIPS performance at 33MHz processor clock. The DragonBall VZ also provides a UART, Timer/PWM, Parallel I/O, LCD Controller, DRAM/SDRAM Controller, SPI, and RTC.

## System Memory

The module provides up to 8 MB of FLASH ROM and up to 32 MB of SDRAM. These are configured as 16-bit wide memories. The SDRAM controller has been configured to use self refresh and also supports CAS-before-RAS refresh cycles. Low power mode control also comes into effect on the MC68VZ328.

The LCD utilizes the main system memory as the display memory. With SDRAM there is a single LCD DMA cycle transfer.

## Memory Map

The Dragonball VZ has four pairs of chip selects, CSA0 & CSA1, CSB0 & CSB1, CSC0 & CSC1, and CSD0 & CSD1. Individual chip selects are not completely configurable; rather, the chip selects are configured as pairs. Chip select pairs share a base address (the addressable region of the second chip select begins immediately after the addressable region of the first), the size of the addressable area (relative to the base address), the number of wait states, and whether it is an 8-bit or a 16-bit chip select.

When SDRAM is enabled, the Dragonball VZ consumes five of the chip selects. CSB1, CSC0, CSC1 become WE, RAS, CAS and CSD0, CSD1 become CS suitable for SDRAM only. The 16-bit flash has been assigned to CSA0, because that is the only chip select active after reset. The wait states are set for internal timing.

The 16-bit CY7C09449 PCI interface is a synchronous interface and must be attached to CSB0, which is configured for external timing (“infinite” wait states).

The RTL8019 ethernet chip supports either 8/16-bit interfaces, but because most NE2000 compatible drivers have been written for an 8-bit interface, the device has been interfaced as an 8-bit device attached to CSA1, the last available chip select. Since the chip select pair must be configured as 16-bit to support the 16-bit flash, the registers of the ethernet chip will appear at every other byte address rather than a block of contiguous bytes. Said a little differently, each 8 bit register maps to a corresponding word address where only half of each word is used.

| Address Range | Function | Chip Select |
|---|---|---|
| 0x00000000 to 0x000003FF | interrupt vector table | |
| 0x00000400 to 0x01FFFFFF | SDRAM (32 MB) | CSD0 (CSD1) |
| 0x01FFFFFF to 0x0FFFFFFF | unimplemented space | |
| 0x10000000 to 0x103FFFFF | FLASH ROM | CSA0 |
| 0x11000000 to 0x107FFFFF | Realtek Ethernet/CAN/USB Controller | CSA1 |
| 0x10800000 to 0x1FFFFFFF | unimplemented space | |
| 0x20000000 to 0x2001FFFF | PCI | CSB0 |
| 0x30000000 to 0x400000000 | PCI I/O mapped peripherals | |
| 0x400000000 to amount needed | PCI memory mapped peripherals | |
| end of PCI peripherals to 0xFFFFEFFF | unimplemented space | |

**Figure 3. Memory Map**

## I/O Memory

The mapping of the I/O Memory into the CPU's main memory takes place at 2 different locations.

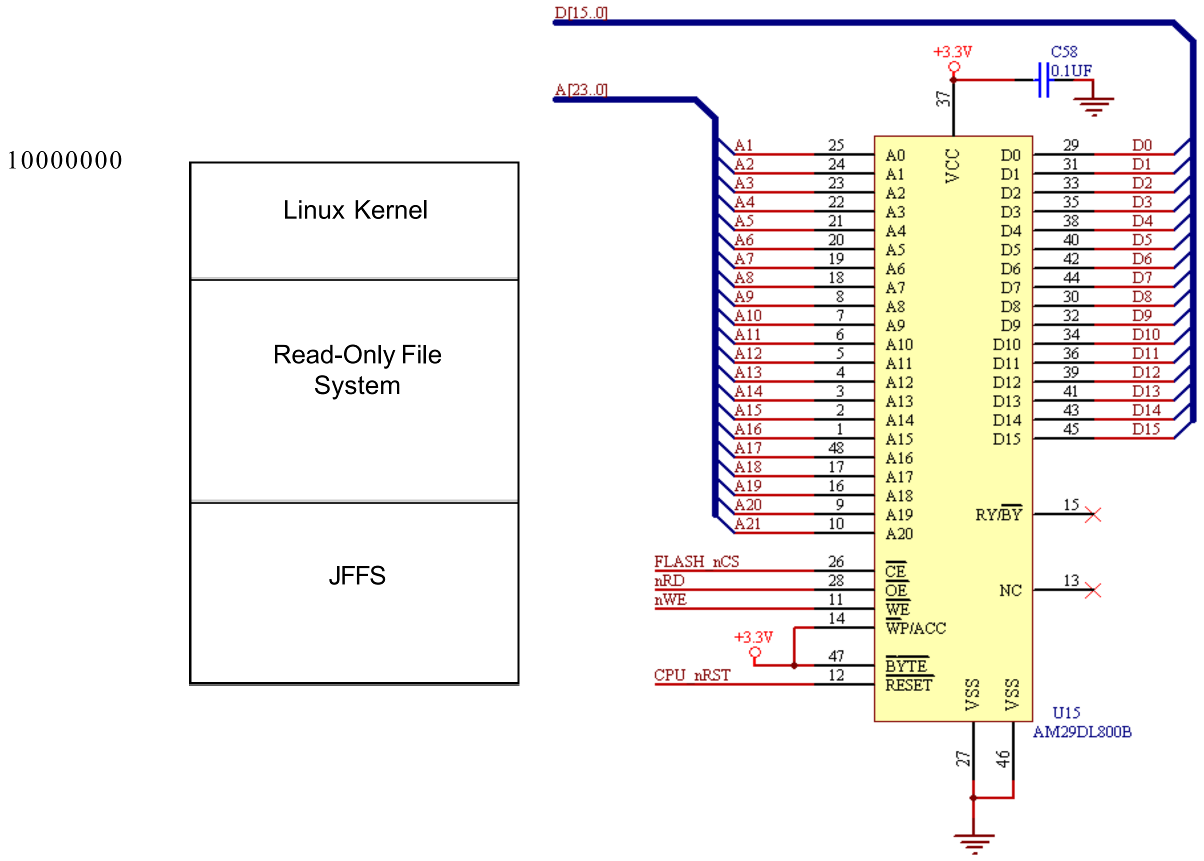
At 0xFFFFF000 the DragonBall VZ registers and boot microcode fill the available memory to the end of the CPU memory. For more detailed information on the DragonBall VZ Registers and the DragonBall VZ Boot Microcode consult the DragonBall VZ Users' Manual (located on the CD).

The Ethernet controller on the NETdimm is mapped off the DragonBall VZ's CSA1 chip select, and is located at 0x10400000. Programming information for the Realtek RTL8019AS Ethernet Controller is not included in this document and may be found in the RTL8019AS Datasheet (located on the CD).

## FLASH ROM

The Flash ROM used on the dimmPCI™ is the AMD29DL322D or compatible 3.0V FLASH ROM. The exact Flash part or size is dependant on the current FLASH in stock or available on the market. The Flash is located at 0x10000000 in memory.

A portion of the Flash has been allocated for use with the Journaling Flash File System (JFFS). The JFFS is mounted under the '/usr/' directory in the standard µClinux distribution. For more information on the JFFS consult Appendix B. The rest of the Flash contains the read-only file system.



10000000
Linux Kernel
Read-Only File System
JFFS
D[15..0]
A[23..0]
+3.3V
C58
0.1UF
VCC
A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20 A21
A0 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15 A16 A17 A18 A19 A20
D0 D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D13 D14 D15
RY/BY
NC
FLASH nCS
nRD
nWE
CPU nRST
CE
OE
WE
WP/ACC
BYTE
RESET
VSS
VSS
U15
AM29DL800B

**Figure 4. Layout of the Flash and Flash Schematic**

## Layout of the Flash

Flash memory stores the following system components:

- The Linux kernel, located at the beginning of flash.
- The root file system as a read-only file system situated immediately after the kernel.
- The Journaling Flash File System, which starts on the first sector boundary after the root file system.

No special consideration is given to the Flash boot sectors, since there is no monitor or special bootstrap. At reset, Flash memory is located at address 0x00000000 and is mirrored throughout the memory since it is controlled by chip select CSA0. At bootup, the kernel, being at the beginning of flash, is run immediately. One of the first actions of the kernel is to define the flash to its working position in the memory map and to initialize SDRAM to address 0x00000000.

## SDRAM

The SDRAM used on the dimmPCI™ is the MT48LC4M16A2 or compatible 3.0V SDRAM. The exact SDRAM part or size is dependant on the current SDRAM in stock or available on the market. The SDRAM is located at 0x00000000 in memory so that the interrupt vector table will be located in SDRAM.

* NOTE * Setting the registers to recognize different SDRAM sizes doesn't work as explained in the Motorola Application Note AN2148-D rev 5.0. Instead a few jumper resistors select the SDRAM size.

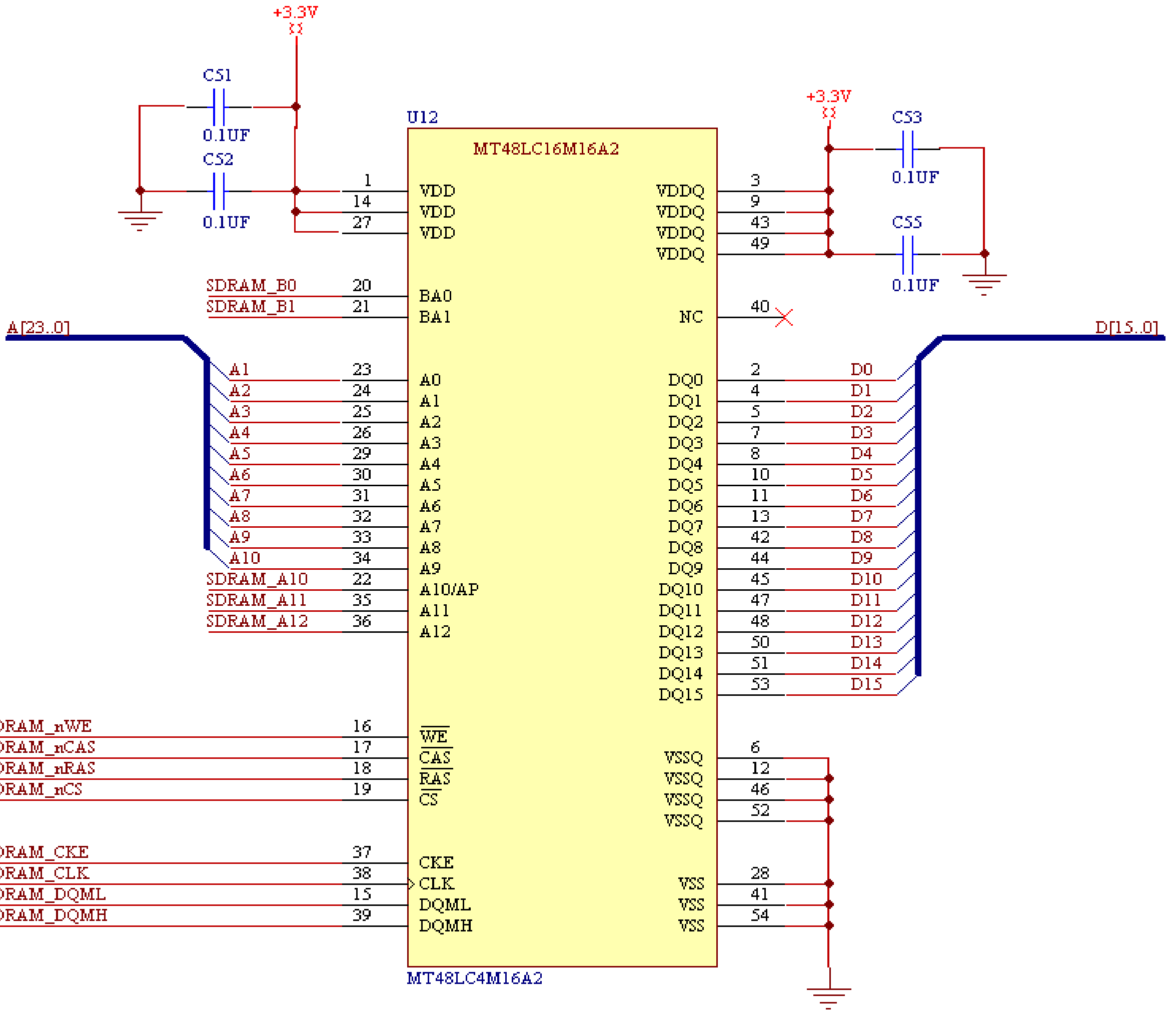


**Figure 5. SDRAM Schematic**

## Ethernet Controller

The dimmPCI™ contains an on board RealTek RTL8019AS Ethernet controller and all the supporting circuitry to implement a 10BaseT ethernet port with no external components. The drivers have been written and implemented by the µClinux operating system running on the dimmPCI™. No support is provided with the exception of the AMC Technologies Corporation provided IEEE assigned MAC address. Below shows how the MAC address can be obtained.

The ethernet 8-bit peripheral is attached to the 16-bit chipset via chip select CSA1 as explained in the memory map section.

### Viewing the Ethernet MAC ID

One way to view the MAC ID is to simply reboot. One of the boot messages that scroll past displays the MAC ID.

A utility exists called ‘ifconfig’ that when executed displays the current network information. ‘ifconfig’ displays “hwaddr” which is the MAC ID of the module. There are two utilities to set the IP address as outlined in Section 3.

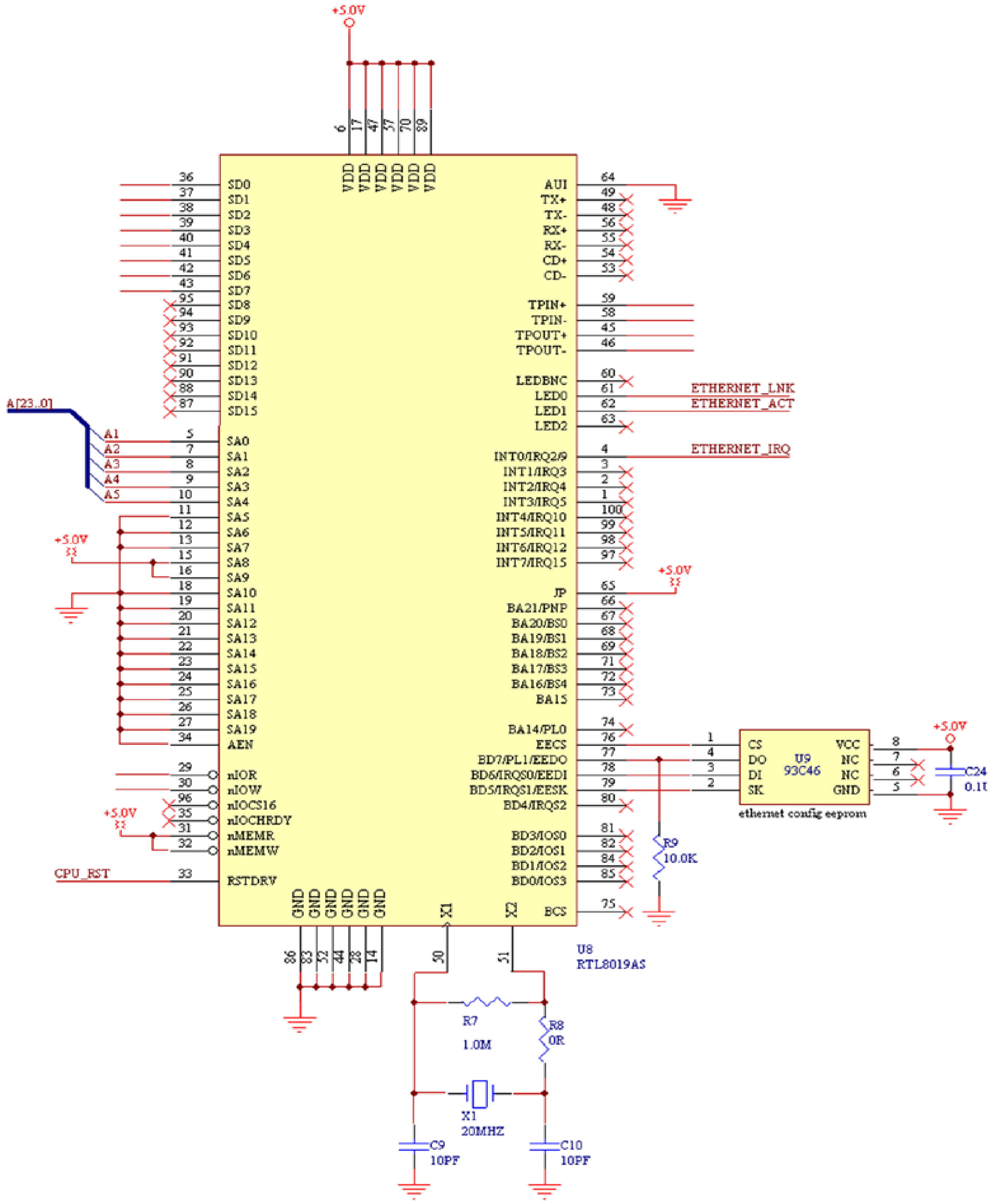


Figure 6. NETdimm Ethernet Schematic

## Digital I/O

The Motorola MC68VZ328 processor provides numerous general purpose I/O lines to the dimmPCI™. The lines which have not been assigned to their dedicated functions can be used for digital I/O.

Depending on the options compiled into the kernel, a number of pins on the dimmPCI™ module can be used for digital I/O. The configuration procedure for setting up the digital I/O functions is outlined in Appendix D1.

## IOdimm

The IOdimm module can be used as a stand-alone or as a peripheral dimmPCI device. Instructions for setting up the IOdimm to be used as a peripheral device are provided in Appendix D2.

The IOdimm provides general purpose input and output. The IOdimm can provide up to 8 digital inputs, 4 digital outputs, 8 12-bit analog inputs and 2 12-bit analog outputs. Figures 7.1-7.4 shows the schematics for the digital and analog I/O. The IOdimm also have general purpose I/O lines that are provided by the Motorola processor as mentioned earlier. However, the IOdimm has its own driver for the SPI pins and therefore these pins will not be available for use by this driver (refer to Digital I/O application note in Appendix D).

The MAX1203 pic is used to convert analog signals to digital signals and the TLV5618A is used to convert digital signals to analog signals. The schematices for the digital to analog converter (DAC) and the analog to digital converter (ADC) are shown in Figures 7.5 and 7.6 respectively.

The IOdimm signals are summarized in Figure 7.7. Only pins 1-29 are described in the table. Pins 30-84 have the same signals as the NETdimm. Those signals are shown in Figure 10.

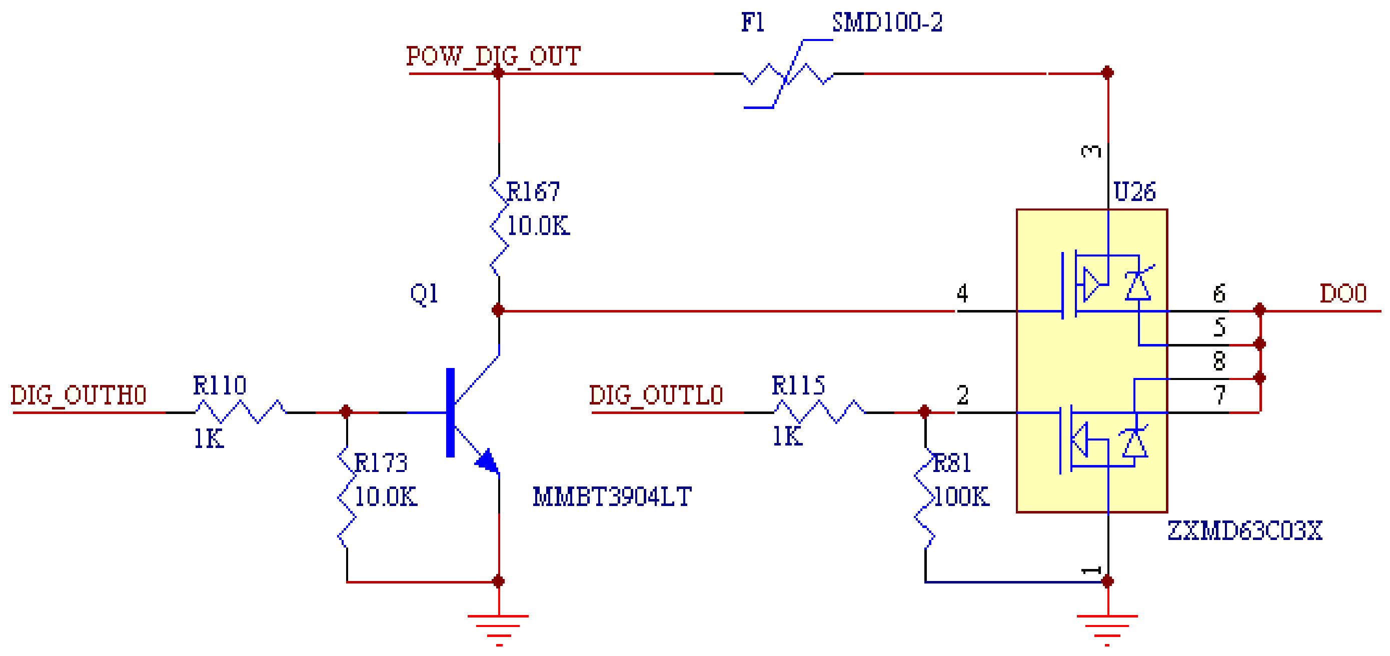


**Figure 7.1 Digital Output Schematic**

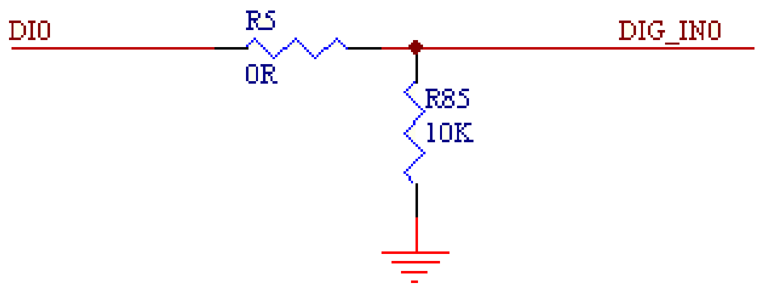


**Figure 7.2 Digital Input Schematic**

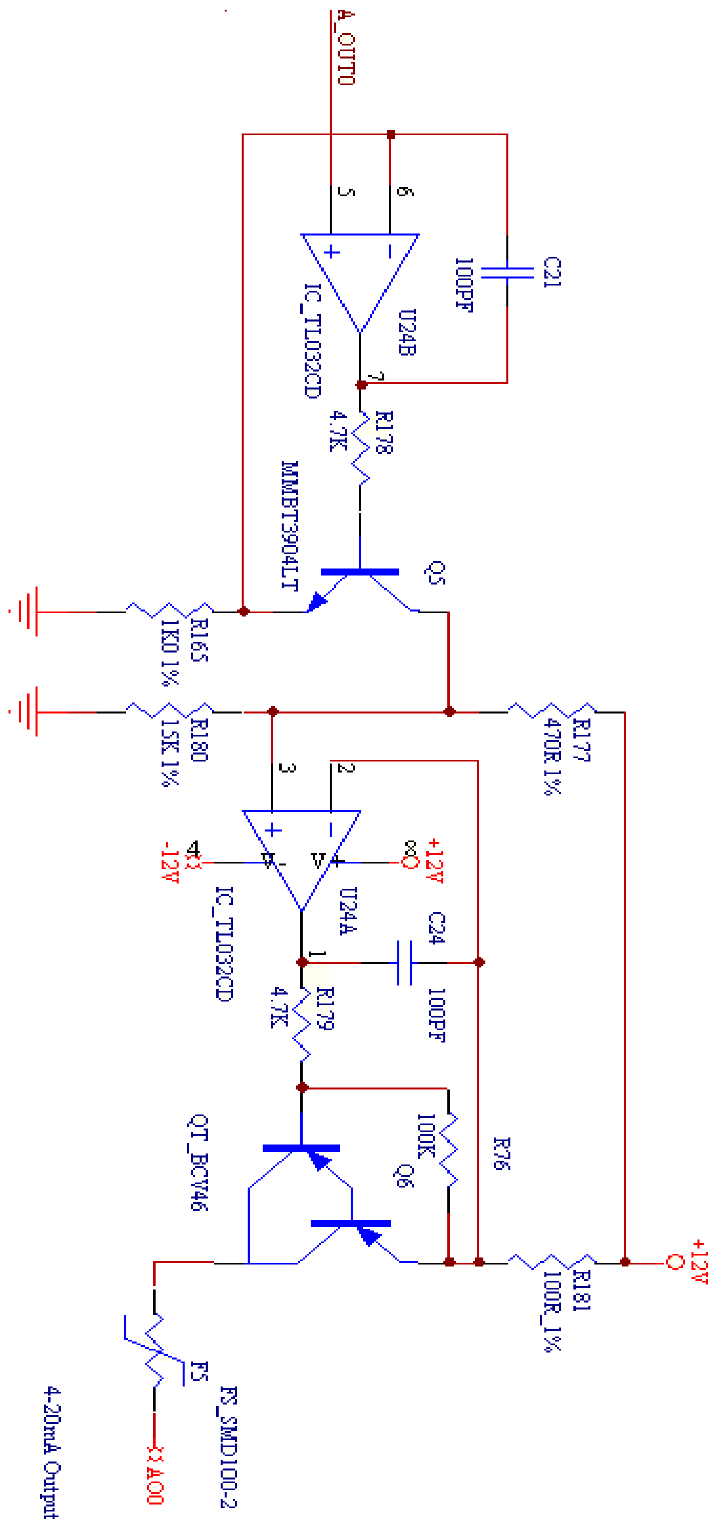


**Figure 7.3 Analog Output Schematic**

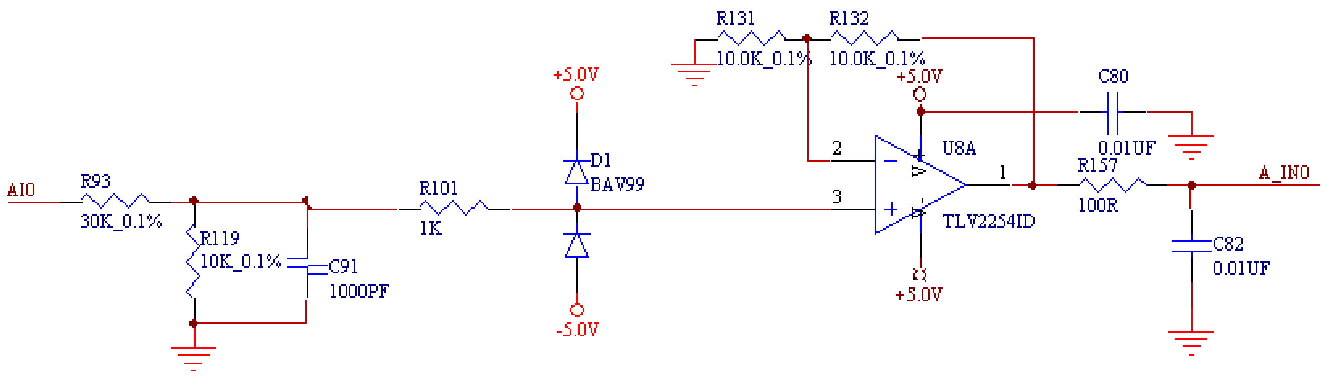


**Figure 7.4 Analog Input Schematic**

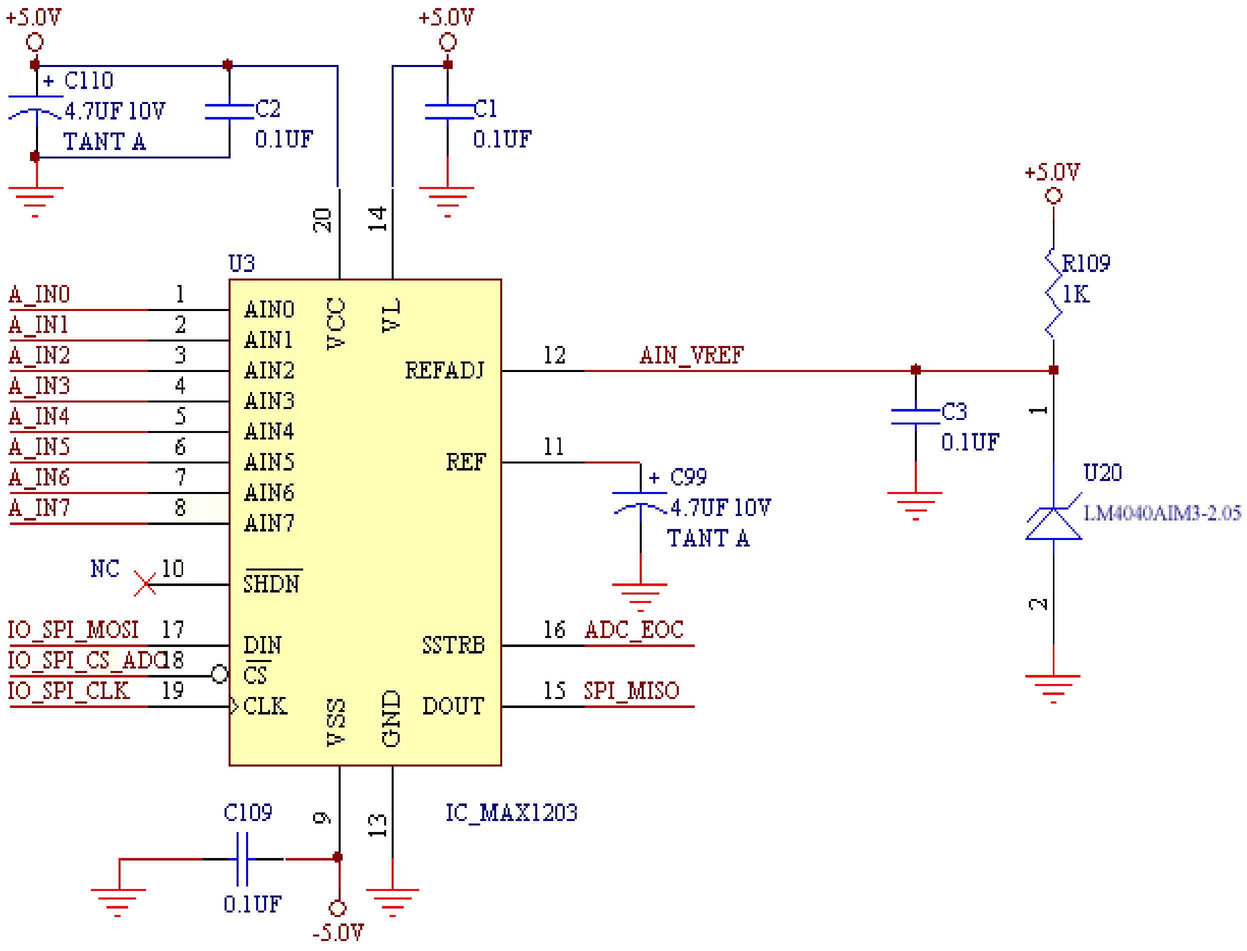


**Figure 7.5 Analog to Digital Converter Schematic**

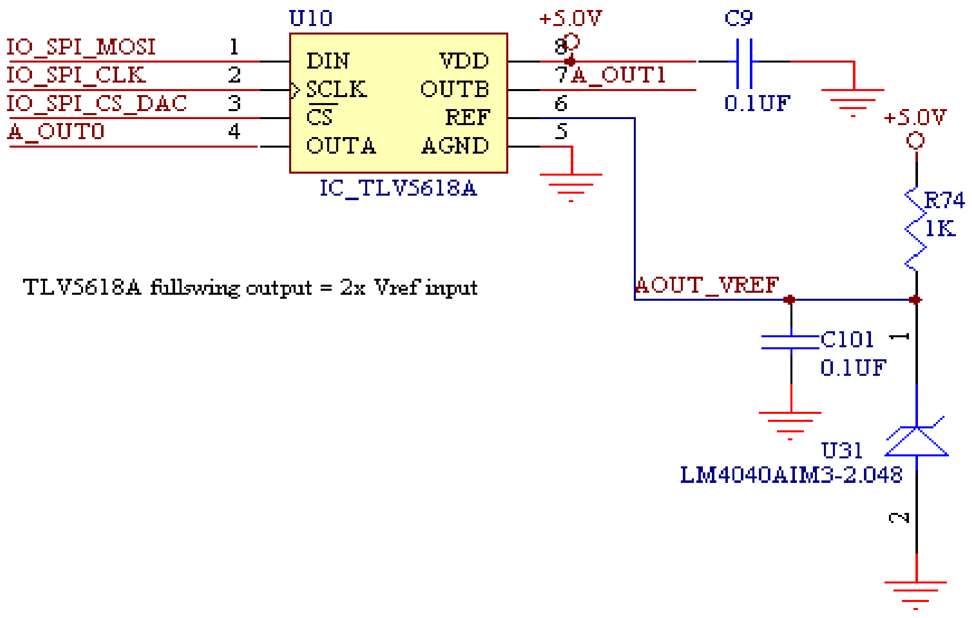


Figure 7.6 Digital to Analog Converter Schematic

| Pin # | SideA | SideB |
|---|---|---|
| 1 | Analog In 0 | Analog In 1 |
| 2 | Analog In 2 | Analog In 3 |
| 3 | VIO | VIO |
| 4 | VIO | VIO |
| 5 | Analog In 4 | Analog In 5 |
| 6 | vbatt | earth gnd |
| 7 | Analog In 6 | Analog In 7 |
| 8 | emu brk | vee |
| 9 | Analog Out 0 | Analog Out 1 |
| 10 | UART2 a+ | UART2 b- |
| 11 | UART1 rts | UART1 cts |
| 12 | UART1 rx | UART1 tx |
| 13 | ee clk | ee mosi |
| 14 |  | ee miso |
| 15 | Digital In 0 | Digital In 1 |
| 16 | Digital In 2 | Digital In 3 |
| 17 | Digital In 4 | Digital In 5 |
| 18 | Digital In 6 | Digital In 7 |
| 19 | Digital Out 0 | Digital Out 1 |
| 20 | Digital Out 2 | Digital Out 3 |

Figure 7.7 IOdimm Signals

## RS-232

The dimmPCI™ provides a 10-pin header terminal RS232 port on the backplane capable of running at up to 230400bps. RS232 line drivers are integrated and no external components are required. The RTS and CTS lines are usable on the DCE configuration of the RS232 port. The DCD (Data Carrier Detect), DSR (Data Set Ready) and DTR (Data Transmit Ready) lines are not implemented on the dimmPCI™ and are all connected to each other. The Ring Indicator line is not implemented on the dimmPCI™ so no external serial devices can be intrinsically powered by RS232 serial port.

The RS-232 10-pin connector is compatible with an insulation displacement connector (IDC) DE9S (female 9-pin DB9 connector)

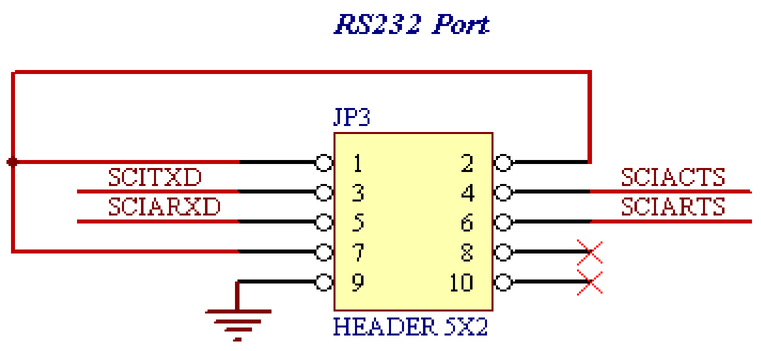


**Figure 8. RS-232 Schematic**

## Watchdog

The watchdog on the dimmPCI platform can be used to protect the system and individual processes. When the process or the system hangs, the watchdog will force a reset.

### Highlights

- Based on the Dallas DS1832 (3V version of the DS1232) watchdog
- Uses '/dev/watchdog' as do the normal Linux watchdogs.
- The number of seconds remaining until timeout is available by reading the device.

```
cat  /dev/watchdog
```

- Multiple processes may be individually registered with the watchdog, each providing its own timeout time. Each process must update the watchdog within its own timeout interval or the system will reset.
- A process may unregister itself at any time.
- At least one process must register with the watchdog within 3 minutes of bootup or else the watchdog will reset the system. If '/sbin/watchdog &' is specified in the '/etc/rc' file, it will register itself and keep the watchdog happy indefinitely (until another process registers itself).

## Usage

Processes to be protected will register using the 'WATCHDOG_REGISTER' IOCTL. The process passed is the desired number of seconds before timeout. The ID (required for watchdog update and deregistration) is passed out.

Update the timer with the 'WATCHDOG_TICKLE' IOCTL. The ID provided by the registration is passed in.

Before the process exits, it should deregister itself with the 'WATCHDOG_UNREGISTER' IOCTL. The ID provided by the registration is passed in.

For example code see Appendix A.

## SPI

A standard SPI bus is included on the dimmPCI™. This SPI bus is located on the DIMM socket occupying pins 23-29 on both the A and B-sides. The SPI bus allows developers the opportunity to create their own DIMM socket cards containing SPI devices and the availability to interface these cards with the dimmPCI™. The SPI bus provides an easy and affordable low-cost alternative to PCI. However the SPI can only be used in low-bandwidth applications.

Currently in this version of the software development kit, we are not providing any drivers for the SPI. The official release will contain several generic SPI drivers.

## LCD Interface

The dimmPCI™ backplane has an LCD connector that is fully supported by the dimmPCI™ module. The LCD connector is designed for a 4-bit LCD panel. The LCD's contrast can be adjusted by sending a PWM signal over the LCONTRAST line. The device driver, in the future, will allocate a block of memory for the LCD.
Information about how to hook up a LCD to the backplane can be found in Appendix D1.

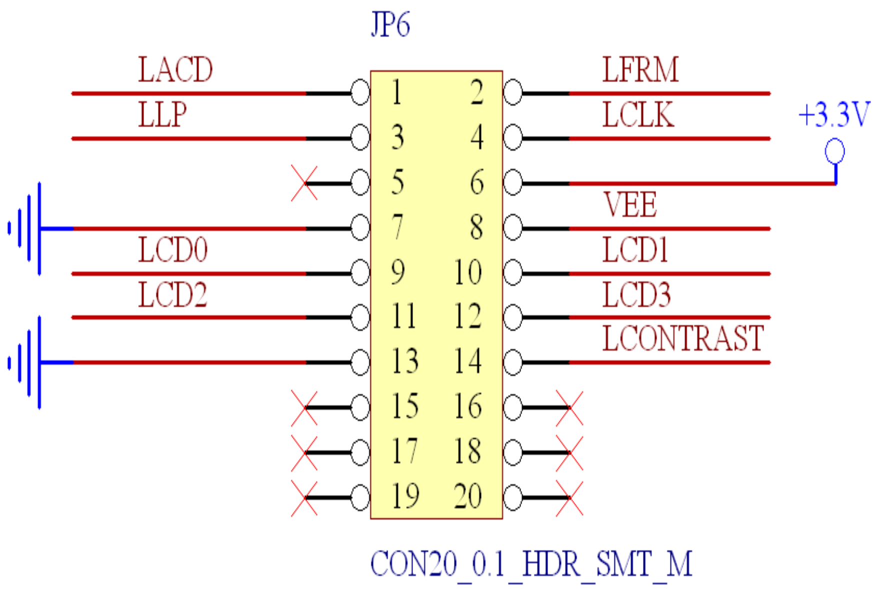


**Figure 9. LCD Schematic**

## dimmPCI™ Signal Descriptions

| Pin # | SideA | SideB |
|---|---|---|
| 1 | ETHRX- | ETHTX- |
| 2 | ETHRX+ | ETHTX+ |
| 3 | | |
| 4 | | |
| 5 | ETHLNKLED | ETHACTL |
| 6 | VBAT | EGND |
| 7 | P/D | EMUIRQ |
| 8 | EMUBRK | EMUCS |
| 9 | Ground | Ground |
| 10 | SCIB+ | SCIB- |
| 11 | SCIARTS | SCIACTS |
| 12 | SCIARXD | SCIATXD |
| 13 | Reserved | Reserved |
| 14 | LCONTRAST | Reserved |
| 15 | LFRM | LLP |
| 16 | LCLK | LACD |
| 17 | LCD1 | LCD0 |
| 18 | LCD3 | LCD2 |
| 19 | Ground | Ground |
| 20 | USER | USER |
| 21 | +5V | D- |
| 22 | D+ | Ground |
| 23 | +5V | SPIINT1 |
| 24 | SPIINT0 | CS0 |
| 25 | CS1 | CS2 |
| 26 | CS3 | SS |
| 27 | MISO | +5V |
| 28 | Ground | MOSI |
| 29 | SCLK | Ground |
| 30 | +3.3V (I/O) | +3.3V (I/O) |
| 31 | AD[01] | AD[00] |
| 32 | Ground | AD[02] |
| 33 | AD[03] | Ground |
| 34 | AD[05] | AD[04] |
| 35 | +3.3V | AD[06] |
| 36 | AD[07] | +3.3V |
| 37 | AD[08] | C/BE[0]# |
| 38 | M66EN | AD[09] |
| 39 | AD[10] | Ground |
| 40 | AD[12] | AD[11] |
| 41 | Ground | AD[13] |
| 42 | AD[14] | +3.3V |
| 43 | C/BE[1]# | AD[15] |
| 44 | +3.3V | PAR |
| 45 | SERR# | Ground |
| 46 | +3.3V | SBO# |
| 47 | PERR# | SDONE |
| 48 | LOCK# | +3.3V |
| 49 | Ground | STOP# |
| 50 | DEVSEL# | Ground |
| 51 | +3.3V | TRDY# |
| 52 | IRDY# | Ground |
| 53 | Ground | FRAME# |
| 54 | C/BE[2]# | +3.3V |
| 55 | AD[17] | AD[16] |
| 56 | +3.3V | AD[18] |
| 57 | AD[19] | Ground |
| 58 | AD[21] | AD[20] |
| 59 | Ground | AD[22] |
| 60 | AD[23] | +3.3V |
| 61 | C/BE[3]# | IDSEL |
| 62 | +3.3V | AD[24] |
| 63 | AD[25] | Ground |
| 64 | AD[27] | AD[26] |
| 65 | Ground | AD[28] |
| 66 | AD[29] | +3.3V |
| 67 | AD[31] | AD[30] |
| 68 | +3.3V(I/O) | Reserved |
| 69 | REQ# | Ground |
| 70 | Ground | GNT# |
| 71 | CLK | +3.3V(I/O) |
| 72 | Ground | CLK1 |
| 73 | CLK2 | Ground |
| 74 | SYSEN# | CLK3 |
| 75 | RST# | PRST# |
| 76 | +5V | +3.3V(I/O) |
| 77 | INTD# | +5V |
| 78 | INTB# | INTC# |
| 79 | +5V | INTA# |
| 80 | REQ3# | +5V |
| 81 | REQ2# | GNT3# |
| 82 | Ground | GNT2# |
| 83 | REQ1# | +12V |
| 84 | -12V | GNT1# |

**Figure 10. dimmPCI™ signals for System Slot**

Pins 1-5 on the DIMM socket control the Ethernet port on the NETdimm™. Pins 6-8 control the In-Circuit Emulator. Pins 9-13 control the UART port. Pins 14-20 control the LCD. Pins 21-22 control the USB port. Pins 23-29 control the SPI. Finally, pins 30-84 control the PCI bus.

## PCI

The PCI interface on the dimmPCI™ CPU module is constructed around a Cypress CY7C09449PV-AC bus controller. This controller is an integrated PCI bridge, master/slave direct memory access controller (DMAC), message transport unit (I2O) and contains 32kbytes of dual ported memory (DPRAM).

The local bus (LB) may access four areas with the CY7C09449; an 8K direct access window into any of the PCI address spaces (memory, I/O or configuration space), the 32kbyte DPRAM, the I2O FIFOs, and the control registers. Any PCI master may access only the last three areas; further, PCI masters may not access the local bus (neither the CY7C09449 nor the 68VZ328 support this).

The DPRAM may be used as either source or destination for PCI DMA transfers, which may be initiated locally (as a master) or by another host (as a target).

The CY7C09449 is attached to a 32-bit synchronous local bus. An Altera EPM7032AE FPGA is required to attach the CY7C09449 to the 16bit asynchronous bus of the Dragonball VZ.

When the dimmPCI™ CPU module is used in the system slot (slot 1), SYSEN line is pulled low; the 7032AE performs various PCI central resource functions including RESET generation, CLOCK generation and bus REQUEST and GRANT arbitration.

### PCI BIOS

The PCI BIOS establishes a software interface between the PCI device drivers and the CY7C09449 hardware. When the dimmPCI™ CPU module is in the system slot, the PCI BIOS also performs the scanning and initialization of devices attached to the PCI bus. Base memory and I/O addresses are assigned, as are the shared PCI interrupt request lines.

Expansion ROMs (used by PC compatible video cards and the like) are not supported, as the Dragonball does not support the x86 code.

The PCI BIOS includes the standard 'pcibios_read/write_config_byte/word/dword' functions. All PCI spaces are defined to be small endian. The Dragonball, which is large endian, has been attached to the C7C09449 such that word accesses do not require byte swapping; byte accesses require toggling the least significant address bit. This is made transparent by the PCI BIOS and has been extended to include ‘readb/readw/readl and writeb/writew/writel’ functions.

The PCI BIOS also includes extensions to perform DMA transfers, and to manage the DPRAM. Drivers may request a transfer using shared DPRAM. Drivers for high bandwidth devices may request a private and permanent allocation of the DPRAM. The DMA mechanism allows the device driver to block or not until the requested transfer(s) have completed. The PCI BIOS uses interrupt driven code to manage the request queues.

### PCI DRIVERS

The ‘/proc/pci’ may be used to display a list of active PCI devices.

## Electrical Characteristics

| | |
|---|---|
| • Operating Voltage (nominal) | 3.3VDC / 5VDC |
| • Operating Current | 75 mA @ 3V with PCI |
| | 36 mA @ 5V with PCI |

## Maximum Ratings

| | |
|---|---|
| • Operating temperature | 0 to +70 degrees C |
| • Storage temperature | -20 to +85 degrees C |

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# 3 uClinux Installation

## Installing the dimmPCI$^{TM}$ System Builder Kit

### Before beginning

This development kit requires an x86 compatible PC running some variant of linux. It will not work under any version of Windows. If linux is not installed on your computer, Redhat linux can be downloaded from http://www.redhat.com In addition root access is necessary for this entire process due to the fact that regular users do not have adequate permissions.

## Installation

Put the install CD in the CD-ROM drive, depending on the linux configuration the CD will likely be available in either of the following directories.

```
/mnt/cdrom
/cdrom
```

If it is not automatically mounted to the file system, try this

```
mkdir /cdrom
mount -t iso9660 -o ro /dev/cdrom /cdrom
```

Approximately 60M free in your '/opt' directory is needed for this next step. When the CD has been mounted, go to the '/cdrom' directory and type

```
make install
```

The Makefile will automatically install all the packages into the '/opt/' directory. Should you at any point wish to remove the dimmPCI SDK software from your computer, you mount the CD-ROM as previously described and run

```
make clean
```

This will remove the development tools and their links. Note: any additional files that you may have added to the SDK directories will also be removed.

## Configuring and compiling the µClinux kernel

**NOTE:** this step must be completed before creating an image file.

The kernel source files are contained in the '/opt/uClinux/linux' directory. From that directory the operation of the kernel can be customized. Base configuration files are available in the '/opt/configs' directory. To use one of these configurations, copy the file to the '/opt/uClinux/linux' directory and rename it to '.config' (Note the period at the beginning of the filename). At this point a backup copy of the existing kernel should be made, in case the new one doesn't work.

```
cd /opt/uClinux/linux
cp linux.bin linux.bin.backup
```

To change the kernel options, use the make utility to configure the source code. **NOTE:** this step must be followed even if not changes are being made to the configuration. Either a graphical configuration process:

```
make menuconfig
```

or a command line style interface can be used:

```
make config
```

After the changes have been made or if a recompile of your kernel is needed for any reason, type the following commands:

```
make clean
make dep
make linux.bin
```

These commands will create a new `linux.bin` file from scratch. Once this is done, a new filesystem image should be created to take advantage of the new kernel.

## Creating a ROM image

Before using the development hardware a file system will need to be created for use on it. The '/opt/fs' directory contains the tools necessary to create a filesystem image. From this directory run the Makefile. The first time you run this it will compile all the tools that will be used on the dimmPCI platform itself, subsequently it will create an image for download.

```
make imagez.bin
```

An explanation of some of the more important files and sub-directories in the '/opt/fs' directory:

| | |
|---|---|
| `imagez.bin` | - this contains both the µClinux kernel and the filesystem, ready to be programmed to the dimmPCI platform. |
| `linux` | - a link to where the µClinux kernel source and binaries reside. |
| `romdisk` | - the set of files that will make up the root file system on the dimmPCI module. |
| `src` | - source code for each of the tools available on the dimmPCI module. |

Any time after the files have been modified in the romdisk directory, typing the following will create a new image file:

```
make imagez.bin
```

This will compress the filesystem and the 'linux.bin' kernel file into a single image file, 'imagez.bin'. The one file is all that is necessary to program onto the dimmPCI CPU module in order for it to operate properly.

## Customizing the filesystem

Before programming the dimmPCI module for the first time, the filesystem should be configured so that it does what is wanted from it the first time. These are the files, which control the startup and initialization process in the filesystem. They are stored in the '/opt/fs/romdisk/etc' directory. The files are:

| | |
|---|---|
| `inetd.conf` | - this file contains information on which internet services the board will provide |
| `inittab` | - determines which program will handle communication on the serial ports |
| `issue` | - the file that is displayed anytime someone tries to log onto the board |
| `passwd` | - contains login/password information, this file is ignored by the current login program |
| `rc` | - this script is run right after kernel initialization, anything that runs at startup should be put in this file. |
| `resolv.conf` | - stores the IP address of the current nameserver |
| `services` | - associates service names with port numbers for internet servers in 'inetd.conf' |

Initially the IP settings should be statically configured for the unit by commands in the 'rc' file. Additionally an NFS mount can be set up at this point to save time. Look ahead at the guide to using NFS for more information.

## Accessing your dimmPCI development board via the serial port

Since the development board has no display or keyboard, the standard console has been routed to the serial port. Using the serial port the development board can be controlled and monitored similar to a linux PC.

1. First take the serial cable out of the box and connect it between the development board and the computer.

2. Next run either 'minicom' or 'xminicom' on the PC, depending on whether X windows is being used or not.

3. Configure minicom to run at 115200 baud with 8N1 and no flow control.

4. Finally power up the development board and a login screen should appear after a few seconds.

5. The username is root and the password is blank.

6. Upon successful login you will see a '#' prompt.

## Accessing the Network

The kernel supplied with the dimmPCI™ CPU module supports TCP/IP networks (IPX is not supported at this time). Before the network may be accessed, the dimmPCI™ CPU module must obtain an IP address.

The subnets 10.xxx.xxx.xxx, 172.16.xxx.xxx, and 192.168.xxx.xxx are reserved for local area networks. Addresses are either statically assigned or dynamically allocated using DHCP (static IPs are still possible as the DHCP server allows specific MAC ID to IP mappings). The dimmCPU module may be configured with either a static or dynamic IP.

### Static IP

A static IP is selected running ‘ifattach’ from the ‘/etc/rc’ script. The ‘ifattach’ is called first without parameters to release any network bindings. The second call specifies the desired address, mask and gateway, followed by the interface name (eth0). Network access is immediately available after the ‘ifattach’, therefore it is common practice to mount network drives with subsequent lines in the /etc/rc file.

For example, to select the IP 192.168.10.141 on a network using the subnet 192.168.10.xxx, use:

```
/sbin/ifattach
/sbin/ifattach –addr 192.168.10.141 –mask 255.255.255.0 \
               –net 192.168.10.0 –gw 192.168.10.1 eth0
```

* NOTE * the backslash may be used in a script file to break a long line over several lines.

### Dynamic IP

A dynamic IP is obtained by running ‘dhcpcd’ from the ‘/etc/rc’ script. The ‘dhcpcd’ is called in background mode with a number of parameters.

The ‘-p’ option forces the daemon to run in persistent mode, retrying indefinitely until an IP is obtained; without it, the daemon will abort if a DHCP server cannot be located.

The ‘-c’ option specifies a command file (the functionality of this option deviates slightly from the typical 0.70 version of 'dhcpcd') which is executed when an IP is first obtained, or should the IP address change (the common operation is to execute every time an IP lease is renewed). The command is invoked with zero or more parameters. Often the command is '/bin/sh', and the parameter is a script file.

If the '-v' option is specified, the IP address is written to 'stdout' as the command file is invoked. Unlike 'ifattach', the IP address is not immediately obtained; the command file is executed when the IP has been obtained. At this point, network access is available; therefore it is common practice to mount network drives using the command file.

For example, the '/etc/rc' file contains:

```
/sbin/dhcpcd -p -c /etc/dhcpcd.sh &
```

and the '/etc/dhcpcd.sh' file contains:

```
echo "We have network access!"
/sbin/ifconfig
mount [...]
```

## Accessing your dimmPCI development board via telnet

If the dimmPCI™ development board is connected to an IP network, it can be accessed using telnet, just like using a serial interface. To take advantage of this, the IP address of the board needs to be known. It will be stored in the '/etc/rc' file in the 'romdisk' directory. Suppose the address of the board is 192.168.10.51. Type the following command.

```
telnet 192.168.10.51
```

A login prompt will appear. The procedure for logging in is the same as for the serial interface. Enter 'root' as the username, and press 'Return' at the password prompt. Note that the telnet access procedure is the same as that of the serial console connection.

## Compiling your own source code

The cross compiler for the DragonBall processor onboard the dimmPCI module is installed along with your kernel source and file system so it should be ready for use. In the 'dimmpci' directory, create a new directory called source.

```
cd ~/dimmpci
mkdir source
cd source
```

Create a simple 'hello world' C program called 'hello.c' such as this:

```
#include <stdio.h>

void main() {
      printf("Hello World\n");
}
```

Now run the GCC compiler to create the binary file. Links should be set up so the compiler is in the path. If not add '/opt/uClinux/bin' to the path and everything should work fine.

```
m68k-pic-coff-gcc hello.c -o hello
```

Once the hello world program has been successfully compiled, copy the resulting binary file to the romdisk directory and create a new image file.

```
cp ~/dimmpci/source/hello /opt/fs/romdisk/usr
cd /opt/fs
make imagez.bin
```

Now program the image file to the dimmPCI™ CPU module and connect to it using the serial port. Run the hello program in the root directory and, sure enough, it will print out 'Hello World'.

You can use a 'Makefile' as well to automate the compiling process if you have multiple files or special options, etc.

## Using NFS to streamline the development cycle

If reprogramming of the dimmPCI™ CPU module were necessary every time changes were made, more time would be spent reprogramming than writing source code. Assuming that both the linux PC and the dimmPCI™ development board are connected via ethernet the solution is to make part of the computer's hard drive available on the dimmPCI filesystem using NFS. First an entry will need to be added to the '/etc/exports' file of the host computer similar to the following:

```
/(home directory)/dimmpci/source    (rw)
```

Of course you will need to add the home directory. This will allow anyone read and write access to that portion of the file system. This is acceptable if on a private network, but highly undesirable if the computer is on the internet. See the man pages for the exports file if the NFS share needs to be secure.

After adding that line to the exports file a restart is necessary for the NFS server process, if it was running in the first place, to load the changes made to the file.

For the next step, the IP address of the computer must be known. If it's not known, in a console window type `ifconfig` and a screen similar to this will appear:

```
eth0  Link encap:Ethernet  HWaddr 00:50:BA:48:3E:D6
      inet addr:192.168.10.34  Bcast:192.168.10.255
      Mask:255.255.255.0
      UP BROADCAST RUNNING  MTU:1500  Metric:1
      RX packets:11509 errors:0 dropped:0 overruns:0 frame:0
      TX packets:2342 errors:0 dropped:0 overruns:0 carrier:0
      collisions:0 txqueuelen:100
      Interrupt:12 Base address:0x9400
```

In this case the IP address would be 192.168.10.34. Next mount the NFS share on the dimmPCI file system. Depending on whether the dimmPCI CPU module is using DHCP or a statically assigned IP address the following command will be placed in one of two configuration files. If a static IP is being used, edit the '/opt/fs/romdisk/etc/rc' file. Conversely if DHCP is being used, this command will have to be placed in the '/opt/fs/romdisk/etc/dhcpcd.sh' file. For a static IP add the following toward the end of the file, right before the 'exit 0' line. For a DHCP system add this line to the end of the dhcp command file.

```
/bin/mount -t nfs 192.168.10.34:/path/to/share /mnt
```

Of course the IP address will be different than the one in this example. Following the IP address put the same path as is in the '/opt/fs/romdisk/etc/exports' file. Once finished a new image file may be created and programmed onto the dimmPCI™ CPU module.

After rebooting the CPU module, there will be access to the files on the PC from the dimmPCI development board in the '/mnt' directory. Now code can be recompiled on the PC and the binaries will be instantly available on the development board.

## Updating Applications on your dimmPCI module

There are two methods for updating applications on the dimmPCI module: (1) create a new image file with the updated application, or (2) copy the updated application to the flash filesystem. Of course the latter option will be preferable in most situations since it is faster and easier.

### Method 1:

The first step is to copy the new application file(s) to the somewhere in the ‘romdisk’ directory on the development computer. Next follow the procedure to create a system image file, and then program it to the target dimmPCI module using one of the previously described methods.

### Method 2:

Note: this method assumes the board has been connected to an IP network and the flash filesystem is in use previous to this procedure.

Create an NFS share on the development computer that contains the updated application file(s). Power up the target dimmPCI$^{TM}$ module and log on to it using either the serial or telnet interface. Mount the share on the dimmPCI module and simply copy the file(s) from the NFS share to the flash filesystem.

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# 4 Programming Mode

## Programming the uC68VZ328

There are two methods of reprogramming the flash of the dimmPCI. The first (and preferred) method uses a program named ‘loader’ run on the Dragonball VZ to read a flash image from a networked file system (usually an nfs share on the development platform).

When a network file system is unreachable, as is the case when the kernel has been corrupted, the second method uses a program named ‘oops’ run on the development platform to communicate via a serial port with the Dragonball VZ that is running in bootstrap mode. For more detailed information about oops, refer to appendix D6. Appendix D6 includes details about how oops works, the purpose of files that are used with oops, and command-line options.

### loader

To use ‘loader’, the following steps must be followed:

1. Mount the network file system that contains the new kernel file. For the purposes of this example, we will assume an nfs share ‘/nfs_share’ exists on the server at 192.168.10.1:

```
mount -t nfs 192.168.10.1:/nfs_share /mnt
cd /mnt
```

2. The nfs share ‘/nfs_share’ should contain the program ‘loader’ and the new kernel file ‘imagez.bin’. The ‘loader’ program can be found in the ‘/opt/boottools/loader’ directory while the ‘imagez.bin’ file can be created in the ‘/opt/fs’ directory’.

```
loader kernel.bin
```

3. The loader program will identify the type and location of the flash device, and then load the kernel image and display the size of the image, which should be between 800,000 and 1,000,000 bytes.

4. The loader program will prompt before proceeding (‘yes’, all lower case, must be entered to confirm programming the flash).

5. All processes will be halted, and the programming will begin. The progress is shown by a '.' displayed every 4kbytes. An 'E' indicates the erasure of a flash sector. When complete, verification will begin automatically. The dimmPCI will reboot automatically upon successful programming and verification. If errors are found, the address will be reported, and another attempt to reprogram the flash will begin (up to three attempts maximum).

### Notes:

1. Invoking 'loader' with a '-e' option will erase the entire flash. This is useful to erase the journal flash file system to prevent it from becoming corrupted as a kernel expands into a new 64kbyte sector.

```
loader imagez.bin -e
```

2. Invoking 'loader' with a '-v' option will perform a "verify" only.

```
loader imagez.bin -v
```

3. It is possible to run loader from a telnet session. However, once the programming begins, the progress indication will be sent only to the console. The telnet session can be reconnected once the programming is complete and the dimmPCI reboots.

4. The 'loader' program was written to be loaded from a network file system into RAM. Although the 'loader' program can be copied into the ROM file system or the journal flash file system, it cannot be run 'in-place', and therefore must be copied to the ramdisk before it can be used.

### oops

The following are brief instructions on how to use oops. For more details about how oops works, refer to Appendix D6.
The oops directory contains:

1. The 'oops' executable (which must be compiled the first time using gcc on the development platform. There is a Makefile included in the /opt/boottools/'oops/src' directory for this purpose)
2. 'init.b' containing the initialisation sequence for the dragonball VZ
3. 'loader.bin' containing the program to write and verify the flash
4. 'kernel.bin' containing the dimmPCI kernel image

To use ‘oops’, the following steps must be followed:

1. Insert the jumper on EMU BREAK and reset the dimmPCI board.
2. Close any terminal software (minicom, etc.) that may be using the serial port (assumed to be /dev/ttyS0).
3. Invoke ‘oops’

```
        cd /opt/boottools/oops
        ./oops -p /dev/ttyS0 -k kernel.bin
```

4. The software will set the speed on the dimmPCI to 115200bps, and begin transferring files, beginning with “init.b” and “loader.bin”. Next the “kernel.bin” file is transferred, which takes approximately 2 minutes. The size and checksum of the kernel image is calculated and displayed.

5. When the loader program and kernel image has been transferred, the loader program is started it begins by displaying the size and checksum of the kernel image, which should match the results in step 4.

6. The loader program then performs a full chip erase, which can take up to 30 seconds. Programming will begin. The progress is shown by a ‘.’ displayed every 4 kbytes. When complete, verification will begin automatically. If errors are found, the address will be reported, and another attempt to reprogram the flash will begin (up to three attempts maximum).

7. When the process is complete, the ‘press reset to reboot’ message will be displayed. The ‘oops’ ‘program will exit after 10 seconds of inactivity on the serial port.

8. Remove the jumper on EMU BREAK and reset the dimmPCI board. The dimmPCI should boot the new kernel.

**Notes:**

1. The default serial port is ‘/dev/ttyS0’

2. The program should be run from the ‘oops’ directory, as component files are expected to be in the current working directory.

3. The default kernel image file is ‘kernel.bin’ in the current working directory. The kernel.bin file is actually a symbolic link to a stable kernel image with a descriptive but lengthy file name.

4. By default, the flash programs erase the entire flash device, which will erase the contents of any complete, partial or corrupt ‘jffs’ filesystem.  In some instances (e.g. to preserve an image of a corrupt file system for analysis), the ‘-em’ option can be selected so that only the minimum number of flash sectors are to be erased.

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# A Appendix

## Sample Code

Included in the '/opt/samples/ directory are several files that show just some of the features available with the dimmPCI platform. The first sample application is a simple hello world program. Its sole purpose is to display a line of text that says "Hello World!" Basically it verifies that your compiler tools and development environment are functioning properly.

```
// hello.c
//
// A very simple program to demonstrate that the development
// environment is properly configured
#include <stdio.h>
void main() {
    printf("Hello World!\n");
}
```

The next sample application demonstrates how file I/O works in a GCC/Linux environment. This program will create a file and write "Hello World!" to it. If you do not have the JFFS functioning you can alternately create a file in the /var directory, since that is also writable.

```
// fileio.c
//
// A program to verify that the flash filesystem works
// properly.
// Upon completion a new file will be created /usr/hello_world
// that contains the text "Hello World!"
#include <stdio.h>
void main ()
{
    FILE *file_handle;
    // create and open the file
    file_handle = fopen ("/usr/hello_world", "w+");
    // check if an error occured
    if (file_handle == NULL) {
          printf (“Cannot open file\n”);
          exit (-1);
        }
        // print the string to file
        fprintf (file_handle, “Hello World!\n”);
        // close the file afterwards
        fclose (file_handle);
    }
```

This application shows how to open and configure the RS485 serial port for communication. It will write the same hello world string to the serial port and then close and exit gracefully.

```
    // serial.c
    //
    // This program opens the RS485 serial port, configures it to
    // run
    // at 9600 bps and transmits a string containing “Hello World”
    #include <stdio.h>
    #include <fcntl.h>
    #include <termios.h>
    void main ()
    {
        int file_handle;
        struct termios io_settings;
        char hello_string[] = “Hello World”;
        // open the serial port
        file_handle = open (“/dev/ttyS1”, O_RDWR);
        // check if an error occured
        if (file_handle == -1) {
          printf (“Cannot open serial port\n”);
          exit (-1);
        }
        // set the serial port speed to 9600 in both directions
        tcgetattr (file_handle, &io_settings);
        cfsetospeed (&io_settings, B9600);
        cfsetispeed (&io_settings, B9600);
        tcsetattr (file_handle, TCSANOW, &io_settings);
        // transmit the string
        write (file_handle, (void *) hello_string, sizeof
            (hello_string) - 1);
        // close the serial port when finished
        close (file_handle);
```

```
}
```

This program will read the date from the kernel clock and print it out to the standard output stream.

```
// date.c
//
// This will read the date from the realtime clock and
// display it on screen.
#include <stdio.h>
#include <sys/time.h>
#include <unistd.h>
void main() {
    struct timeval time_val;
    // read the date from the realtime clock
    gettimeofday(&time_val, NULL);
    // display the value from the clock
    printf(“%s”, ctime((time_t *) &time_val.tv_sec));
}
```

The following program writes a given date to the kernel clock and then commits it to the hardware real-time clock.

```
// rtc.c
//
// This program will first set the date on the real time clock
to
// Fri May 25 10:21:00 2001 and then read it back and display
it.
#include <stdio.h>
#include <sys/time.h>
#include <unistd.h>
void main ()
{
    struct timeval time_val;
    struct tm tm_val;
    // load the time we are setting into the time structure
    tm_val.tm_sec = 0;
    tm_val.tm_min = 21;
    tm_val.tm_hour = 10;
    tm_val.tm_mday = 25;
    tm_val.tm_mon = 4;
    tm_val.tm_year = 2001 - 1900;
    tm_val.tm_wday = 5;
```

```
        // convert it to seconds since 1970
        time_val.tv_sec = mktime (&tm_val);
        // set the time in the linux system clock
        settimeofday (&time_val, NULL);
        // read the date from the realtime clock
        gettimeofday (&time_val, NULL);
        // display the value from the clock
        printf (“%s \n”, ctime ((time_t *) & time_val.tv_sec));
    }
```

This next program is an example of how to activate and manipulate the watchdog timer.

```
    // watchdog.c
    //
    // This sample program demonstrates how to register with
    // the watchdog timer, tickle it, and finally unregister
    // with it.
    #include <stdio.h>
    #include <fcntl.h>
    #include <asm/EZ328watchdog.h>
    void main ()
    {
        int watchdog_id;
        int watchdog_handle;
        int value;
        long arg;
        value = 120;
        arg = (long) &value;
        // open the watchdog timer device and register
        // the timeout period with it
        watchdog_handle = open (“/dev/watchdog”, O_RDWR);
        ioctl (watchdog_handle, WATCHDOG_REGISTER, arg);
        watchdog_id = arg;
        // hit the watchdog (reset the counter)
        ioctl (watchdog_handle, WATCHDOG_TICKLE,
             (long)watchdog_id);
        // unregister with the watchdog, disable the timer
        ioctl (watchdog_handle, WATCHDOG_UNREGISTER,
             (long)watchdog_id);
        close (watchdog_handle);
    }
```

Finally, this source uses the inetd superserver to create a simple network server that will echo any characters received back to the client. This can be demonstrated by telnetting into the host board and typing some characters.

```
// echo.c
//
// All this file does is echo any data written to its standard
// input to it’s standard output. If run from the commandline
it
// will echo typed characters. If you add this line to your
// /etc/inetd.conf file
//
// 24 root tcp nowait /path/to/echo
//
// And then try to telnet to port 24 of your dimmPCI develop-
ment
// board it will echo any charcters sent via the telnet
// connection.
#include <unistd.h>
#include <stdio.h>
int main (void)
{
    char c;
    while (read (fileno (stdin), &c, 1) >= 0) {
      write (fileno (stdout), &c, 1);
    }
    return 0;
}
```

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# B Appendix

## The Journalling Flash File System

There are two different types of memory available on the dimmPCI CPU module, SDRAM and flash memory. The SDRAM is virtually the same as the RAM in a personal computer; anything stored in this memory will be lost when the power is turned off. This is also referred to as volatile memory. The flash memory is analogous to the hard drive in your computer since it retains stored data even when the computer is turned off. This is called non-volatile memory.

The journaling flash file system (JFFS) is an interface that allows data to be written/read to/from the flash memory randomly. It arranges files in the memory, keeps track of how large they are and where they are located etc.

But JFFS is not the only thing that uses flash memory; along with the JFFS there exists the kernel and the read-only file system. Basically the kernel is the operating system, it handles memory allocation, multi-tasking, etc. It is located in the lowest portion of the flash memory. Stored after the kernel in flash is the read-only file system. It contains configuration scripts and user tools, such as ‘cp’, ‘ls’, ‘pwd’ and so on. The remaining flash memory has been allocated for the JFFS, depending on the size of the kernel and read-only file system this can range up to 1.0 Mbytes in size.

In order to have access to this memory, the kernel must have been compiled with JFFS enabled. Next the JFFS needs to be mounted on the JFFS on your root file system. The default location is to mount it under the ‘/usr’ directory. So the command would be:

```
/bin/mount –t jffs /dev/flash0 /usr
```

After executing this command on the dimmPCI console, the ‘/usr’ directory will be a nonvolatile filesystem with read/write capability. Any data stored here will survive turning the power off.

A utility is included in the distribution that will erase all the data stored in the JFFS and reset its configuration.  This may be useful if the filesystem becomes corrupted and needs to be reset. The program is ‘mkjffs’ and can be found in the ‘/sbin’ directory.  In order to use this program, first unmount the JFFS and run ‘mkjffs’.

```
umount /usr
/sbin/mkjffs /dev/flash0
```

A brief note about flash memory life expectancy: Typically a single sector in a flash memory chip can survive over 100,000 erase/write cycles.  This means that for data logging or application updates the flash chip should not fail for a long time.  Assuming 50 erase/write cycles per day, the flash should survive for about five and a half years.  But this also means that the JFFS is not suited to handle any data intensive applications.

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# C Appendix

## Development Tool Chains

A development tool chain is the suite of programs (including the compiler, linker, assembler, disassembler and library generation) used to develop for a specific executable format. This SDK installs three different tool chains:

- The COFF tool chain. This tool chain is used to develop the uClinux kernel. There are no libraries associated with this tool chain.
- The PIC-COFF tool chain. This tool chain is used to develop user applications. It has the PIC-32 extensions already installed, which allow applications larger than 32K in size to be created. This was the original tool chain, and is used to generate the uClinux filesystem executables.
  The library associated with this tool chain is the 'uC-libc' library. This library has been optimized for the embedded environment, and produces exceptionally small executables.
- The ELF tool chain. This tool chain is also used to develop user applications. It is the most common executable format in the Linux world at large, being the default format on most desktop Linux workstations.
  The library associated with this tool chain is the 'uClibc' library. This is a quite complete library and is well maintained. Porting a program to uClinux will encounter the fewest difficulties when the ELF tool chain with the uClibc library is used. The executables produced by this tool chain are noticeably larger that those produced by the PIC-COFF tool chain.

Note: The SDK does not include support for either the COFF or the ELF formats of an executable, as both formats are converted to FLAT format by the linker. The PIC-COFF toolchain does this automatically, while the ELF tool chain requires the '-elf2flt' command line argument (see below).

## Normal Usage of the PIC-COFF Tool Chain

The PIC-COFF tool chain is normally very easy to use. The ‘Hello world’ program supplied in the samples directory is compiled as follows:

```
m68k-pic-coff-gcc hello.c -o hello
```

To compile the same program with the 32 bit extensions:

```
m68k-pic-coff-gcc -fPIC hello.c -o hello
```

## Normal Usage of the ELF Tool Chain

The ELF tool chain included with the SDK does not default to generate code for the Motorola M68VZ328, so additional command line arguments are needed.

```
m68k-elf-gcc -m68000 -elf2flt hello.c -o hello -lc
```

The libraries used must be specified. They must be specified after the source files have been listed.

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# Application Note 1

## Using Digital I/O with dimmPCI Modules

July 4, 2003 Version 0.4

Author: Bernice Lau

## Introduction

For the purposes of direct digital I/O, there are a maximum of 27 general-purpose I/O lines leading from the Motorola MC68VZ328 to the dimmPCI backplane. These lines also have dedicated functions, the LCD, EEPROM, SPI, or ICE_DEBUG, so all lines may not be available, depending on the hardware and the options compiled into the kernel. Digital I/O can be used on a dimmPCI module when in either the system slot or peripheral slot.

The I/O points can be accessed through a character device driver using standard system calls. Upon opening the device on first use, the set of unreserved I/O points will be made available to the user. Pins that have been reserved for their dedicated function will not be accessible. Configuration of the I/O points is achieved through `ioctl` calls, after which reads and writes can be performed.

### Requirements

- dimmPCI passive backplane
- NETdimm, or IOdimm, or CANdimm
- SDK 2.05 or higher (2.0.38 or higher kernel source and filesystem)
- sample programs in SDK, `/opt/samples/user_code/dio`
    - even_parity.c
    - xor.c

## Kernel and Filesystem Configuration

The uClinux 2.0 kernel must have the digital I/O option compiled for proper operation. These options will be set using the kernel configuration

```
      cd /opt/uClinux/linux
      make menuconfig
```

Using this main menu, under **Character Devices** the following must be selected

```
      Digital IO Character Device
```

After saving your configuration changes, use the following commands in the same directory to complete compilation of your kernel.

```
      make clean
      make dep
      make
```

Now, check if the node for the digital I/O character device exists.

```
      cd /opt/fs/romdisk/dev
```

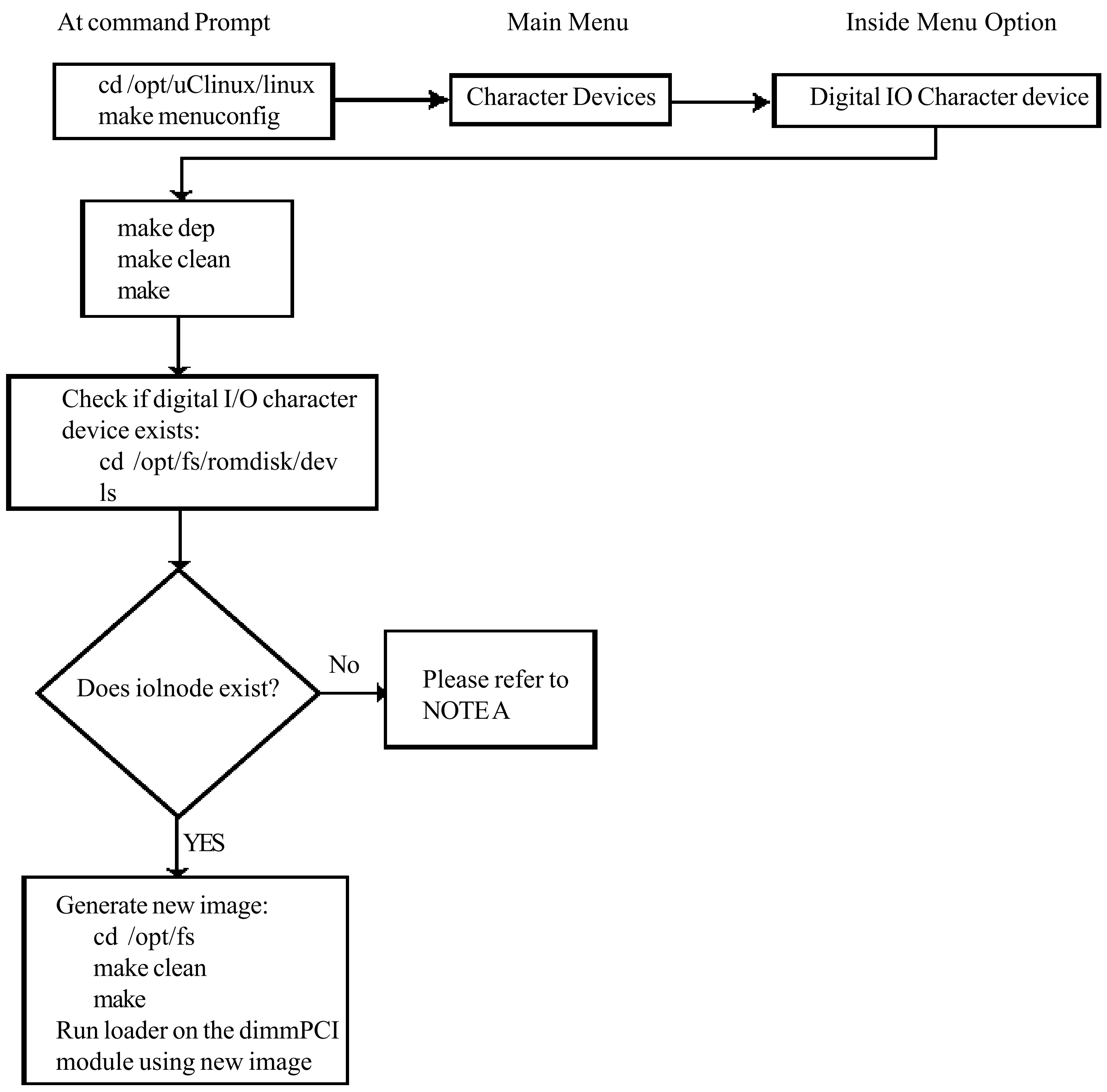
If `io1` exists in this directory, then continue to create the new image in the next step. If it does not exist, please refer to Appendix A for further instructions.

Next a combined image of the new kernel and filesystem is to be created.

```
      cd /opt/fs
      make clean
      make
```

Then use **imagez.bin** and run **loader** on the module to write in the filesystem and kernel. Please refer to the User's Manual for details on running **loader**. The dimmPCI module is now configured for digital I/O.

## Kernel and Filesystem Configuration Flow Chart



## Available Digital I/O Pins

The number of pins available for digital I/O depends on the other options compiled into the kernel. For example, if the EEPROM option is compiled in, then the bits from Port E bits[0-2] will not be available for digital I/O.

During boot up, devices that require pins for their dedicated functions will reserve them, and thus these pins cannot be accessed by the digital I/O character driver. After all other drivers have reserved their required pins, any remaining pins that have not been reserved will be used for digital I/O, and so a user-space program will be able to access these pins via the character device.

In order for the pins to be reserved, a scan of applicable devices is done on boot up. Thus, the same kernel can be used on any of the NETdimm, IOdimm, or CANdimm without having to recompile.

The pins are listed in Table 1 in their suggested order of use. The pins further down the list are more likely to be used for their dedicated functions than those at the top. Table 1 also describes the respective port and bit numbers of each class of pins, as well as their location on the backplane. Only the LCD class of I/O points and Port G/pin5 lead to pin headers on the backplane. The remaining pins must be accessed by soldering wires to the system or peripheral slot on the backplane. The following are notes regarding each class of pins.

The LCD class of pins are only used when an LCD display needs to be hooked up to the dimmPCI module. Thus, they are the least likely to be used for their dedicated function, and have the added advantage of leading to pin headers on the backplane.

The EEPROM class is only needed if an EEPROM is needed to store permanent information. This device is normally not populated on the dimmPCI modules, making it unlikely that the pins will be used for their dedicated function. Note that if the EEPROM is populated, those pins cannot be used for digital I/O, even if the EEPROM driver has not been compiled in.

The SPI pins are used for peripheral interfaces such as an analog-to-digital converter. Note that the IOdimm has its own driver for the SPI pins in order to take care of its I/O functions. Thus, on an IOdimm the SPI pins will not be available for use by this digital I/O driver.

The ICE_DEBUG pins are the in-circuit debugger pins. These pins are more useful as outputs, since they must not be held low on power up. PortG/Pin5 is the EMU break, and access to this jumper pin is needed when running in rescue mode for ‘oops’. Also note that PortG/Pin2 is the EMU IRQ, which is a non-maskable interrupt.

*Table 1: List of all available digital I/O pins*

| Class | Circuit Name | Port | Bit | Backplane System Slot | Backplane Header Pin | Pull-Up/ Pull-Down Resistor |
|---|---|---|---|---|---|---|
| LCD | LCD0 | Port C | 0 | A18 | JP6, pin 9 | Pull-Down |
| | LCD1 | Port C | 1 | B18 | JP6, pin 10 | Pull-Down |
| | LCD2 | Port C | 2 | A17 | JP6, pin 11 | Pull-Down |
| | LCD3 | Port C | 3 | B17 | JP6, pin 12 | Pull-Down |
| | LFRM | Port C | 4 | A15 | JP6, pin 2 | Pull-Down |
| | LLP | Port C | 5 | B15 | JP6, pin 3 | Pull-Down |
| | LCLK | Port C | 6 | A16 | JP6, pin 4 | Pull-Down |
| | LADC | Port C | 7 | B16 | JP6, pin 1 | Pull-Down |
| | LCONTRAST | Port F | 0 | A14 | JP6, pin14 | Pull-Up |
| EEPROM | EE MOSI | Port E | 0 | B13 | | Pull-Up |
| | EE MISO | Port E | 1 | B14 | | Pull-Up |
| | EE CLK | Port E | 2 | A13 | | Pull-Up |
| SPI | SPI nINT0 | Port D | 5 | A24 | | Pull-Up |
| | SPI nINT1 | Port D | 6 | B23 | | Pull-Up |
| | SPI MOSI | Port J | 0 | B28 | | Pull-Up |
| | SPI MISO | Port J | 1 | A27 | | Pull-Up |
| | SPI CLK | Port J | 2 | A29 | | Pull-Up |
| | SPI nSS | Port J | 3 | B26 | | Pull-Up |
| | SPI nRDY | Port K | 0 | B27 | | Pull-Up |
| | SPI CS0 | Port K | 4 | B24 | | Pull-Down |
| | SPI CS1 | Port K | 5 | A25 | | Pull-Down |
| | SPI CS2 | Port K | 6 | B25 | | Pull-Down |
| | SPI CS3 | Port K | 7 | A26 | | Pull-Down |
| ICE_DEBUG | EMU IRQ | Port G | 2 | B7 | | Pull-Up |
| | EMU PD | Port G | 3 | A7 | | Pull-Up |
| | EMU CS | Port G | 4 | B8 | | Pull-Up |
| | EMU BRK | Port G | 5 | A8 | J7, pin 1 | Pull-Up |

## Programming Structure

The structure that should be used to store pin configuration and information is `dimm_io` from **dimmio.h**, located in `/opt/uClinux/linux/include/linux/`. Table 2 below describes the six fields of the structure and their settings.

*Table 2: dimm_io structure description*

| Field | Description |
|---|---|
| port_number | type - short<br>The port number corresponds to the ports of the MC68VZ328, where A = 0, B = 1, C = 2, ... L = 11, M = 12 |
| bit_number | type - short<br>The bit numbers are for each port, where 0 = lsb, ... 7 = msb |
| offset | type - long<br>This is the offset into the list of active pins. The offset has a maximum range of 0 to 26. |
| mode | type - unsigned char<br>The mode determines the direction of the I/O point, where 0 = input, 1 = output |
| state | type - unsigned char<br>The state describes the logic level on the pin, where 0 = low, 1 = highNote that the state field is not updated when an ioctl call is used and field exists only for programming convenience. |
| pull_up_dn | type - unsigned char<br>The pull_up_dn controls the pull-up orpull-down register for each pin, where 0 = disabled, 1 = enabled |

## Digital I/O Functions

The low level functions used to manipulate the digital I/O points are the system calls `open`, `lseek`, `read`, `write`, `close`, and `ioctl`. The uses of these functions are demonstrated in two simple sample programs, `xor.c` and `even_parity.c`.

`open` gives access to the digital I/O character device. It takes two parameters, the node for your device in `/dev` and the mode you wish to open it in. For the digital I/O device, you will want to use the node `/dev/io1` and the mode for read and write `O_RDWR`. This function will return the handle to your device:

```
handle = open("/dev/io1", O_RDWR)
```

`lseek` will choose the current I/O point and takes three parameters including the handle, the offset, and a descriptor for how the offset is used (`SEEK_SET, SEEK_CUR, SEEK_END`). `SEEK_SET` will position the file pointer to an absolute position in the array of active pins as specified by the value in offset. `SEEK_CUR` will move relative to the current position by the number in offset. `SEEK_END` will move the file pointer to the end of the array of active pins. `lseek` should be used to position the file pointer prior to any read or write operation.

```
lseek(handle, pin->offset, SEEK_SET)
```

`read` will read the value of the current I/O point. It takes three parameters, the handle, the byte(s) for the read information to be stored to, and the number of bytes to be read. This function will only allow you to read from the active pins. Reads can be done as a single pin or in a group of contiguous pins. The result of the read will be 0xFF (high) or 0x00 (low). If the read operation was not successful, then an error will be returned. The example below reads one byte into the state field of the `dimm_io` structure.

```
error = read(handle, &(pin->state), 1)
```

`write` sets the value of the current I/O point and it also takes three parameters, the handle, the byte(s) that will be written to the output pins, and the number of bytes to be written. Note that only output pins can be written to, and attempting to write to input pins will generate an error. Similar to reading, write operations can be done for a single I/O point or as a contiguous group of pins. Write values are non-zero for high, and zero for low. The example demonstrates writing one byte from the state field of the `dimm_io` structure. Prior to using this write function, the state (0 or 1) of the pin was specified in the state field.

```
error = write(handle, &(pin->state), 1)
```

`close` will close the digital I/O device and only takes one parameter, the handle for the device. This should be done once the device is no longer needed.

```
close(handle)
```

`ioctl` will configure an I/O point and it will pass control information to the device driver. Each `ioctl` call takes three parameters, the handle, a descriptor of the desired command, and a pointer to a `dimm_io` structure:

```
error = ioctl(handle, DIMM_IO_IOCTL_SET_CONFIG_BY_PORT_BIT, pin)
```

Each of the command descriptors are listed below. If any of them are unsuccessful executing the function, an error will return.

`DIMM_IO_IOCTL_MAP` will return an offset given a port and bit number. The bit and port number must be assigned to `port_number` and `bit_number` in the `dimm_io` structure that is passed to the `ioctl` command. The offset will be assigned to the offset field of the structure if the port and bit number exists in the list of active I/O points, otherwise an error is returned.

`DIMM_IO_IOCTL_RETRIEVE` returns a port and bit number given an offset. The offset must be assigned to the `dimm_io` structure passed to the `ioctl` call. As long as the offset is smaller than the maximum number of active pins, the port and bit numbers in the structure will be set. If the offset does not correspond to an active I/O point, then an error will be returned.

`DIMM_IO_IOCTL_SET_CONFIG_BY_OFFSET` will set the necessary registers to configure the I/O point specified by the offset. Thus, the fields for `offset`, `mode`, and `pull_up_dn` must be set. After the function call, the pin will be configured according to those settings, and the device driver will fill in the corresponding `port_number` and `bit_number` in the structure.

`DIMM_IO_IOCTL_SET_CONFIG_BY_PORT_BIT` will also configure the I/O point, but as specified by the port and bit number in the `dimm_io` structure. Similar to the configuration by offset, the `mode`, and `pull_up_dn` must be set. After returning successfully from the `ioctl` call, the offset for the port and bit number will also be set.

`DIMM_IO_IOCTL_GET_CONFIG_BY_OFFSET` will retrieve the configuration of the I/O point specified by the offset. After successful execution, the fields `port_number`, `bit_number`, `mode`, and `pull_up_dn` will be set with their appropriate information.

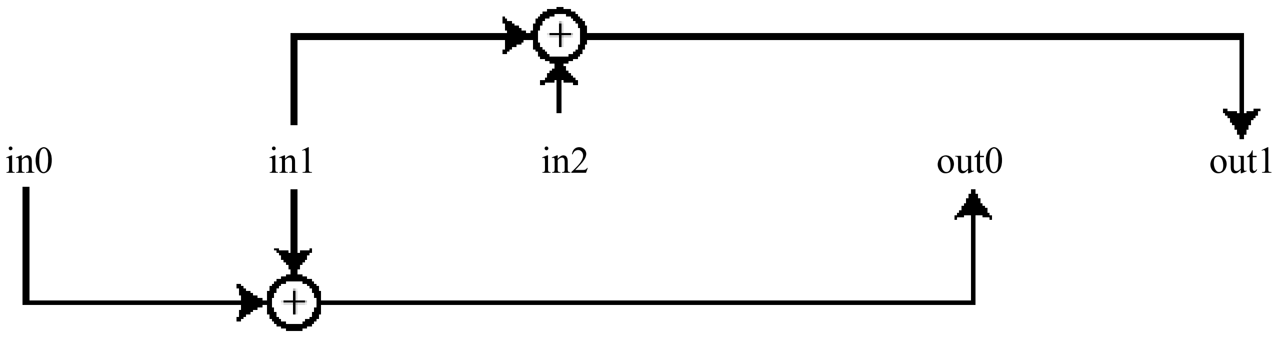
`DIMM_IO_IOCTL_GET_CONFIG_BY_PORT_BIT` will get the settings of the I/O point specified by the `port_number` and `bit_number`. Upon returning from the `ioctl` call, the `offset`, `mode`, and `pull_up_dn` will reflect the hardware settings.

## Sample Programs

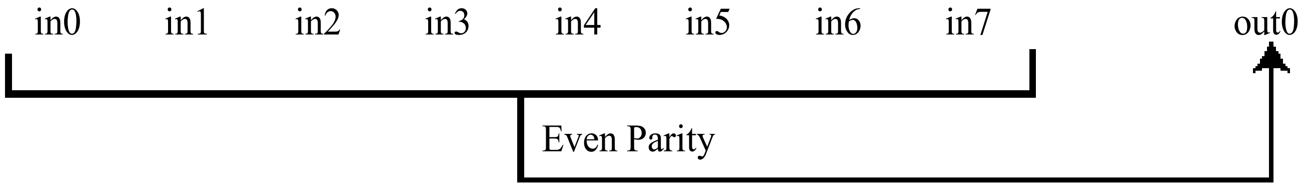
Each of the sample programs **even_parity.c** and **xor.c** demonstrate simple use of digital I/O. The source code for these files is available in the samples directory of the SDK, `/opt/samples`.
**xor.c** performs the XOR logic function on 3 inputs. The XOR is performed on the first two inputs and the result output to the first output. The result of the second and third input XOR are sent to the second output.

**even_parity.c** is a program that will do even parity on 8 input pins, and the result is sent to 1 output pin. Thus, if there is an even number of '1' inputs, then the output will be '0'. Conversely, if there is an odd number of '1' inputs, the output will be '1'.

xor.c



even.c

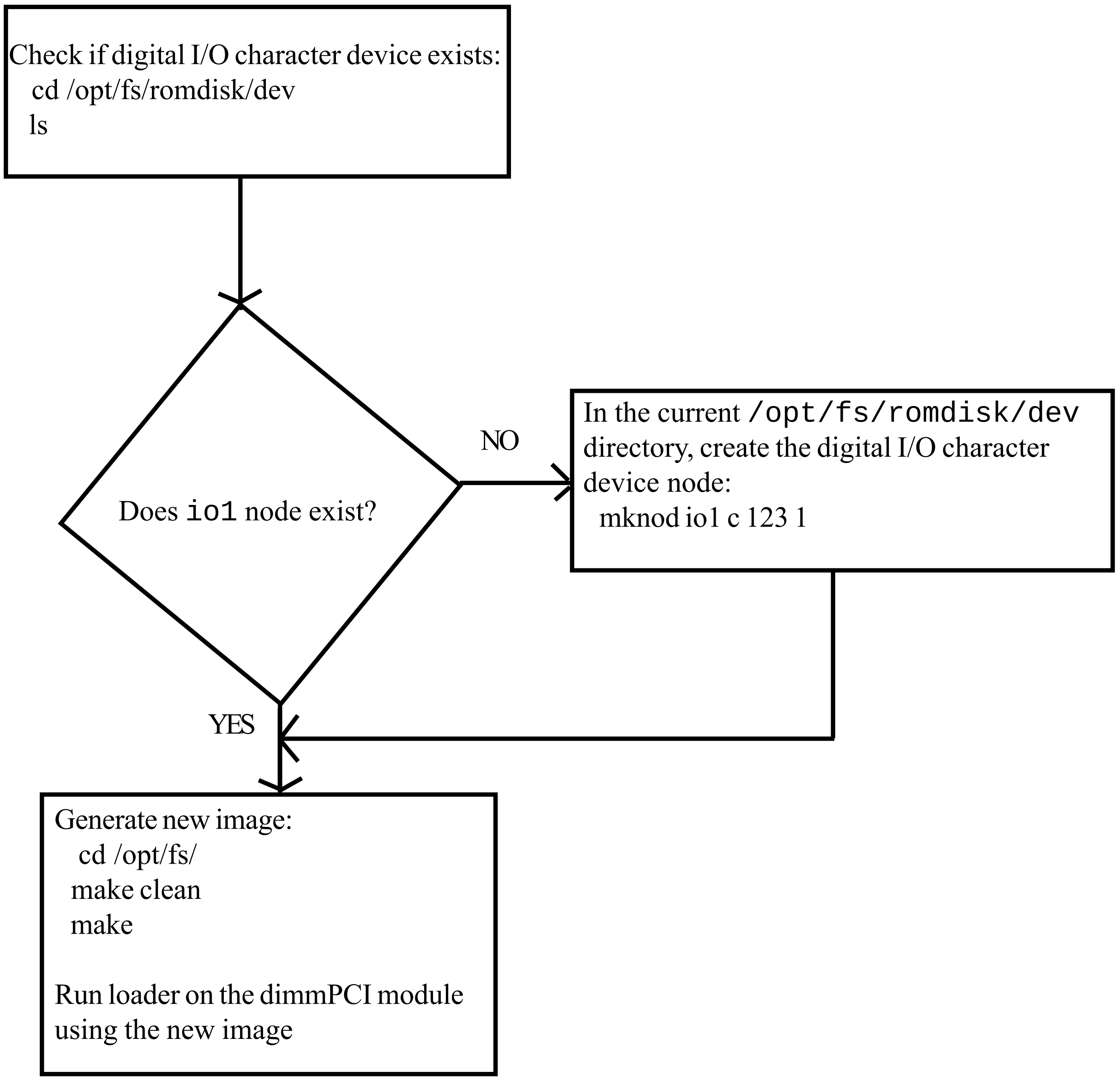


## NOTE A: Creating a node for the character device

Since the node for the digital I/O device does not exist in the `/opt/fs/romdisk/dev` directory, it needs to be created. Create the node by doing the following as `root`, where 123 is the major number and 1 the minor number of the character device `io1`.

```
      mknod io1 c 123 1
```

After the correct node is created, then continue with compiling the kernel and filesystem image. Below is the modified flowchart including the extra step of creating the digital I/O character device node.


Check if digital I/O character device exists:
cd /opt/fs/romdisk/dev
ls
Does io1 node exist?
NO
In the current /opt/fs/romdisk/dev directory, create the digital I/O character device node:
mknod io1 c 123 1
YES
Generate new image:
cd /opt/fs/
make clean
make
Run loader on the dimmPCI module using the new image

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# Application Note 2

## Configuring dimmPCI Modules for Communication

April 21, 2003

Version 0.1

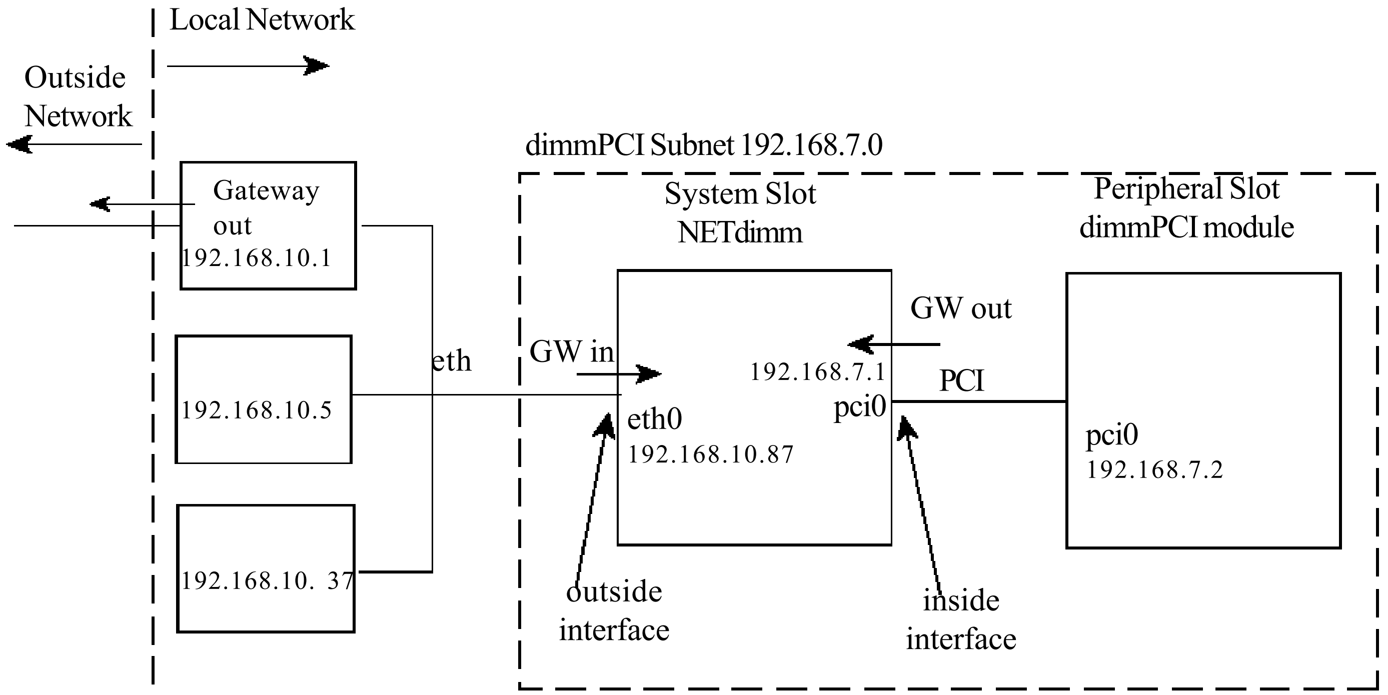
Authors: Bernice Lau, Robert Austen

## Abstract

On a dimmPCI backplane, there are several possible slots in which a dimmPCI may be inserted, the system slot or the peripheral slots. With the correct options compiled into the kernel and system configuration, the two modules can be set up to communicate with each other. The communication is achieved using the PCI I2O transport layer to send ethernet packets over the PCI bus to another likewise configured module.

## Introduction

In order to connect the two dimmPCI modules, it is necessary to set up the hardware as a subnet. A NETdimm must be in the system slot to interface to the local network through the ethernet port.



On the NETdimm in the system slot, the ethernet port, eth0, must be configured to have an IP address on the local network for your host computer. Therefore eth0 acts as a gateway into the dimmPCI subnet for the local area network. It is also the outside interface for your subnet to the local area network.

On the system slot NETdimm, the pci0 device is the inside interface to a second or third dimmPCI module in a peripheral slot. This device will be the gateway used by each peripheral dimmPCI module.

On the peripheral dimmPCI module, only the pci0 interface needs to be configured. This device must be set up to communicate with the pci0 device on the system slot NETdimm.

## Requirements

- dimmPCI passive backplane 1.1
- NETdimm 1.2 or higher for system slot on dimmPCI backplane
- NETdimm 1.3 or higher, or IOdimm or CANdimm for peripheral slot
- 2.0.38 or higher kernel source and filesystem (SDK 2.03 or higher)

Note: When two NETdimm units are used on the backplane, the system slot device will cause the peripheral device to reset as well. A NETdimm 1.3 is required since NETdimm 1.2 in the peripheral slot will not wait for the system slot device on reset and will not get initialised.

The following files and programs will be used:

rc
imagez.bin
loader

## Kernel Configuration

The 2.0 kernel must have specific networking and PCI options included in order for communication to occur between two dimmPCI modules. These options will be set using the kernel configuration

```
cd /opt/uClinux/linux
make menuconfig
```

Using this main menu, under **General Setup** the following must be selected:

```
PCI support
PCI I2O transport layer
PCI networking support
```

The following default values for some PCI settings are already fairly optimal in the **General Setup** menu. It is essential that the PCI frame size be the same for both dimmPCI devices if the default values are not used, since the PCI frame size will set the maximum transmission unit (MTU) size.

```
5 PCI receive frames
2 PCI transmit frames
4 PCI frame size
```

From the main menu, inside of **Networking Options** this option must be set:

```
IP forwarding/gatewaying
```

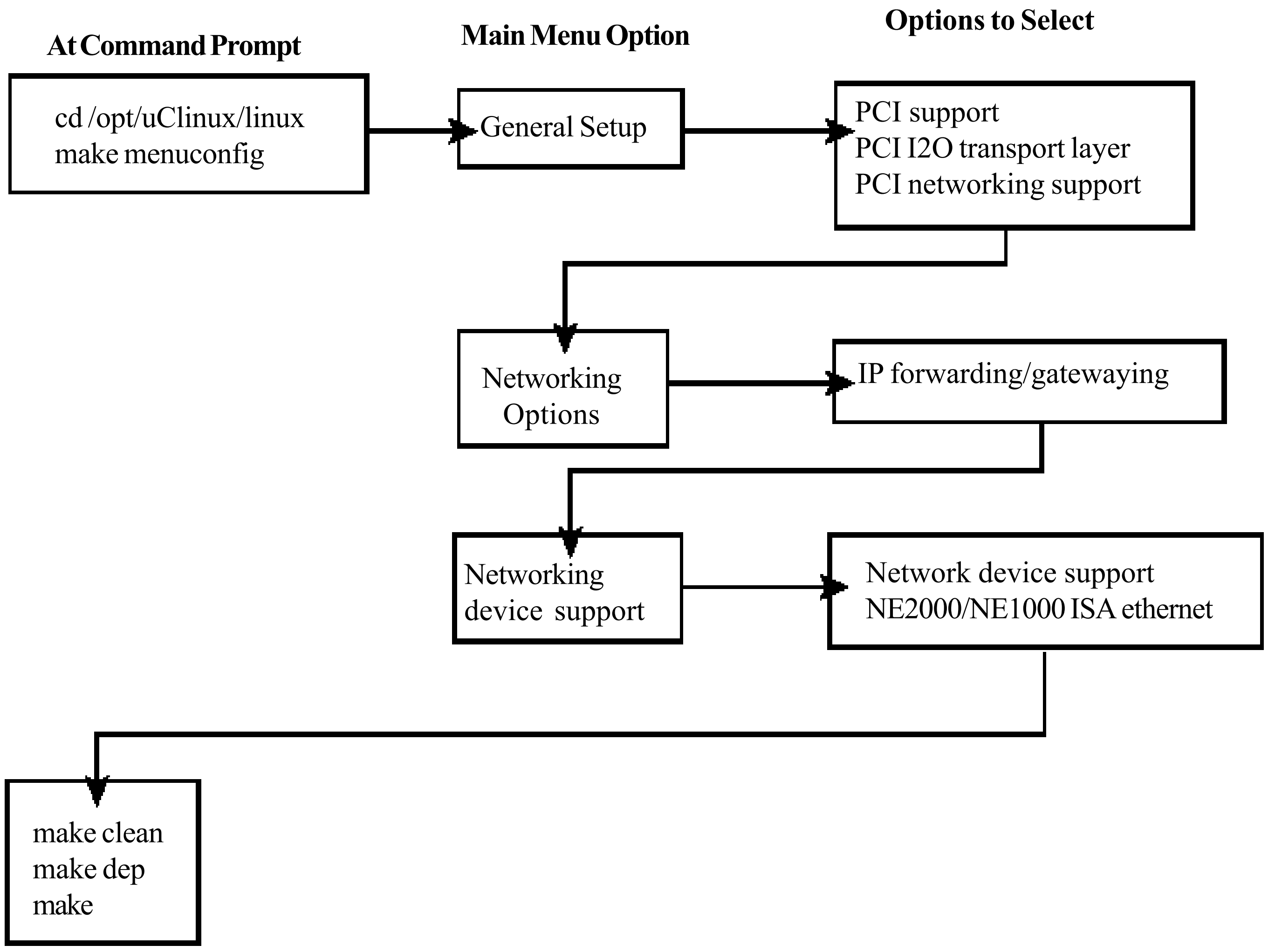
Again, from the main menu under **Network device support**:

```
Network device support
NE2000/NE1000 ISA ethernet
```

After saving your configuration changes, use the following commands in the same directory to complete compilation of your kernel.

```
make clean
make dep
make
```

## Kernel Configuration Flow Chart



## Filesystem Configuration

For the dimmPCI units to be correctly configured for the subnet, the **rc** file must be modified. These different configurations should each be contained in a separate copy of the filesystem, since different applications will be used. Copies of the filesystem can be generated in the following way. Here we will assume that the original filesystem is `/opt/newfs`, and the new filesystems, **sysfs** is for the system slot and **perfs** for the peripheral slot.

```
cd /opt/
cp –Rpdx newfs sysfs
cp –Rpdx newfs perfs
```

|  |  |
|---|---|
| where | R, copy directories recursively |
|  | p, preserve file attributes if possible |
|  | d, never follow symbolic links |
|  | x, stay in this filesystem |

For both the system slot and peripheral slot dimmPCI modules, the 'dhcp' client must be turned off, which can be done by commenting it out with '#' in front of the line. This must be done since the IP addresses and routes are set statically.

The following code should be added to the system slot **rc** file to set the IP information. The **rc** file is located in `/opt/sysfs/romdisk/etc/`, where `sysfs` is the name of filesystem for the system slot.

```
# attach the pci0 and eth0
/sbin/ifattach –addr 192.168.10.87 –net 192.168.10.0 –mask \
 255.255.255.0 –gw 192.168.10.1 eth0
/sbin/ifattach –addr 192.168.7.1 –net  192.168.7.0 -mask \
 255.255.255.0 pci0
```

**eth0** will be set up as a device on the local network, so its address must be on the local network. Here, the local network is on 192.168.10.0 and the IP address has been set specifically to 192.168.10.87. The gateway 192.168.10.1 specifies the machine that acts as an interface between the local network and the outside network, and will be redirecting information from the local network to the subnet you are creating with the two dimmPCI modules. **pci0** will be a device on the PCI subnet, here set as 192.168.7.0 and its IP address is set accordingly as 192.168.7.1.

Note that the '\' character at the end of the lines indicated that the command continues on the next line.

For the peripheral slot dimmPCI module, **pci0** is the only network interface; there is no physical ethernet connection for the peripheral module to set up. This is the code that must be added to a peripheral slot **rc** file in `/opt/perfs/romdisk/etc/`.

```
# attach the pci0
/sbin/ifattach –addr 192.168.7.2 –net  192.168.7.0 \
–mask 255.255.255.0 –gw 192.168.7.1 pci0
```

**pci0** is on the subnet (192.168.7.0), and has an IP address of 192.168.7.2. The subnet for the **pci0** devices on both modules must be the same. For the peripheral module, a gateway must be specified since **pci0** will be the network interface. The gateway value must correspond to the IP address of the system slot **pci0**, 192.168.7.1.

Thus, different **rc** files must be configured for each copy of the filesystem, generating a different image to be loaded for each module. Note that the **eth0** and **pci0** can be configured manually by typing in the specific information at the command prompt on the dimmPCI module, but changes will not be retained upon reboot.

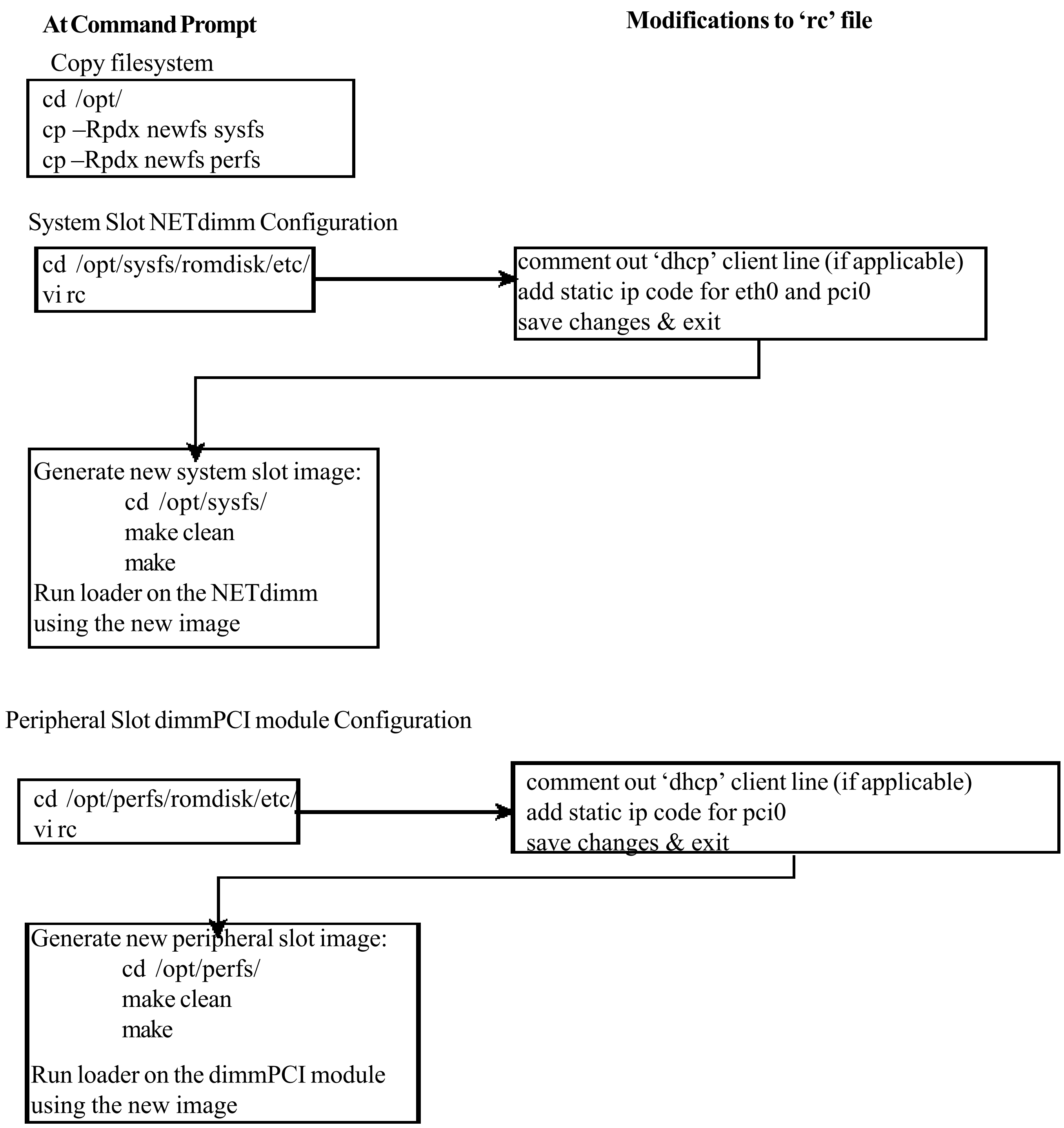
Create a combined image of the new kernel and modified filesystem.

```
      cd /opt/<filesystem name>
      make clean
      make
```

Then use **imagez.bin** and run **loader** on the module to write in the modified filesystem and kernel. Please refer to the User's Manual for details on running **loader**. The dimmPCI module is now configured for communication with another device.

To streamline development, part of the computer's hard drive can be made available using NFS. These changes will occur in the **rc** file.

## Filesystem Configuration Flow Chart



**At Command Prompt**

**Modifications to ‘rc’ file**

Copy filesystem

```
cd /opt/
cp –Rpdx newfs sysfs
cp –Rpdx newfs perfs
```

System Slot NETdimm Configuration

```
cd /opt/sysfs/romdisk/etc/
vi rc
```

comment out ‘dhcp’ client line (if applicable)
add static ip code for eth0 and pci0
save changes & exit

Generate new system slot image:

```
cd /opt/sysfs/
make clean
make
```

Run loader on the NETdimm using the new image

Peripheral Slot dimmPCI module Configuration

```
cd /opt/perfs/romdisk/etc/
vi rc
```

comment out ‘dhcp’ client line (if applicable)
add static ip code for pci0
save changes & exit

Generate new peripheral slot image:

```
cd /opt/perfs/
make clean
make
```

Run loader on the dimmPCI module using the new image

## Host machine Configuration

After configuring the two dimmPCI modules, they can now communicate with each other, as well as the outside network. But the outside network cannot access the dimmPCI subnet. Therefore a route to the subnet must be added to redirect packets to the proper device. The most convenient method is to add the route to the gateway for the local network, in this example it is 192.168.10.1. On the machine that acts as the gateway, the following command would be used at the command line

```
     route add –net 192.168.7.0 netmask 255.255.255.0 gw 192.168.10.87
```

**net** specifies the subnet that you wish to add the route to and **gw** is the gateway into the dimmPCI subnet, the **eth0** IP address on the system slot NETdimm.

## Testing

To test if the configuration was successful and the network was established, execute the following commands.

On the host machine:

| | |
|---|---|
| `ping 192.168.10.87` | (this tests the system slot NETdimm configuration) |
| `ping 192.168.7.2` | (this tests the peripheral slot dimmPCI module configuration) |
| `telnet 192.168.7.2` | (this gives you access to the peripheral slot dimmPCI module) |

In the telnet session for the peripheral slot dimmPCI module:

| | |
|---|---|
| `ping <host machine ip address>` | (this indicates that the peripheral slot dimmPCI module has access to the outside network) |

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# Application Note 4
## Using Multiple NETdimm Modules

Author: Bernice Lau Version 0.1

**Abstract**

On a dimmPCI backplane, there are several possible slots in which a dimmPCI may be inserted, the system slot or the peripheral slots. Once configuration has been completed, the NETdimm modules can successfully communicate with each other. This application note describes the use of the PCI bus sending ethernet packets to transfer a file between two NETdimm devices.

**Introduction**

After configuration of the NETdimm modules has been completed, they can communicate with each other in an ethernet fashion. Two variants of a simple file transfer program have been developed to demonstrate this ability.

The programs **server.c** and **client.c** can run once configuration is done. The programs **inetServer.c** and **inetClient.c** require modifications to `/etc/services` and `/etc/inetd.conf` since they interface with **inetd**. All the programs employ networking sockets in order to communicate.

**Requirements**

- dimmPCI backplane 1.1
- NETdimm 1.2 or higher for system slot on dimmPCI backplane
- NETdimm 1.3 for peripheral slot
- 2.0.38 or higher kernel source and filesystem (SDK 2.05 or higher)
- sample programs in SDK, `/opt/user_code/networking/filetransfer`
    - client.c
    - server.c
    - inetClient.c
    - inetServer.c

Note: When two NETdimm units are used on the backplane, the system slot device will cause the peripheral device to reset as well. A NETdimm 1.3 is required since NETdimm 1.2 in the peripheral slot will not wait for the system slot device on reset and will not get initialised.

Configuration of the NETdimm modules must be completed beforehand, please refer to the application note ‘Configuring dimmPCI Modules for Communication for Kernel v.2.0’.

## Simple Server & Client

The sample programs **server.c** and **client.c** are available in the SDK samples directory, `/opt/user_code/networking/filetransfer/without_inetd`. The programs interact using Internet sockets, AF_INET. Once the sockets have been established they can be read from and written to in order to transfer information. Each program will be run on a separate NETdimm, and using the IP addresses established during configuration, text files such as **hello.txt** can be transferred between them.

The server will set up its own socket and wait for an incoming client socket. Upon accepting a client connection, it will set up a client socket, and go through a series of read and write operations on the socket to accept the file transfer.

On the client side, it will set up a socket and then attempt to connect to a server. Once a connection has been established the socket will be used for reads and writes to the server to transfer the file.

Note that the port that the client and server sockets will connect through must be the same. It has been hard coded in the program during the socket setups.

## Inetd based Server & Client

The sample programs **inetServer.c** and **inetClient.c** are available in the SDK samples directory, `/opt/user_code/networking/filetransfer/with_inetd`. These programs interact through the internet daemon, inetd. Similar to the simple server and client programs, a text file can be transferred between two NETdimms using the IP addresses established during configuration.

The following instructions must be added to the config files of the root file system of both NETdimm modules for the inet based server and client to work. In `/etc/services` the service that needs to be called, **inetServer**, must be added to the list in the format

```
      service-name      port/protocol
      eg.    inetServer  9735/tcp
```

The port number can be chosen arbitrarily, so long as it does not already exist in the **services** list and is not below 1024, which are reserved for system use.

In `/etc/inetd.conf` the program and path that inetd will load must be added in the format

```
service-name endpoint-type protocol wait-status uid server-program server-
arguments
eg.    inetServer stream tcp nowait root /usr/inetServer
```

The server side of the program is started by inetd, allowing the read and write operations to go to standard input and output. **inetd** will listen on all service ports for the services listed in

**inetd.conf**. Upon receiving a connection request, it will start up the server. Therefore the server has no need to set up sockets.

The **inetClient** is very similar to the simple client, since it must still read and write to a socket. The socket is set up using information gathered by the function getservbyname() which will check for the service **inetServer** on the host NETdimm. After confirmation of the service is established, the program will create a socket, connect and transfer the file as before. Unlike the simple client, there is no need to designate the connection port since getservbyname() will retrieve this information.

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# Application Note 5

## Using Analog and Digital I/O with the IOdimm

June 30, 2003 Version 0.1

Author: Bernice Lau

## Introduction

The IOdimm is designed to support dedicated analog and digital I/O. There are 8 analog inputs, 2 analog outputs, 8 digital inputs and 4 digital outputs. All of these I/O channels are accessible from the dimmPCI backplane. User-space programs interact with the I/O channels through a device driver using standard system calls.

## Requirements

- dimmPCI passive backplane
- IOdimm 2.0 or higher
- SDK 2.05 or higher (2.0.38 or higher kernel source and filesystem)
- sample programs in SDK `/opt/samples/card_specific/iodimm`
  - fir.c
  - xor_iodimm.c
  - even_parity_iodimm.c

## Kernel and Filesystem Configuration

The uClinux 2.0 kernel must have the IOdimm SPI option compiled for proper operation. These options will be set using the kernel configuration

```
cd /opt/uClinux/linux
make menuconfig
```

Using this main menu, under **Platform dependent setup** the following options must be selected

```
SPI support for IOdimm
ADC MAX1203
```

After saving your configuration changes, use the following commands in the same directory to complete compilation of your kernel.

```
      make clean
      make dep
      make
```

Next make a copy of the filesystem, specifically for the IOdimm

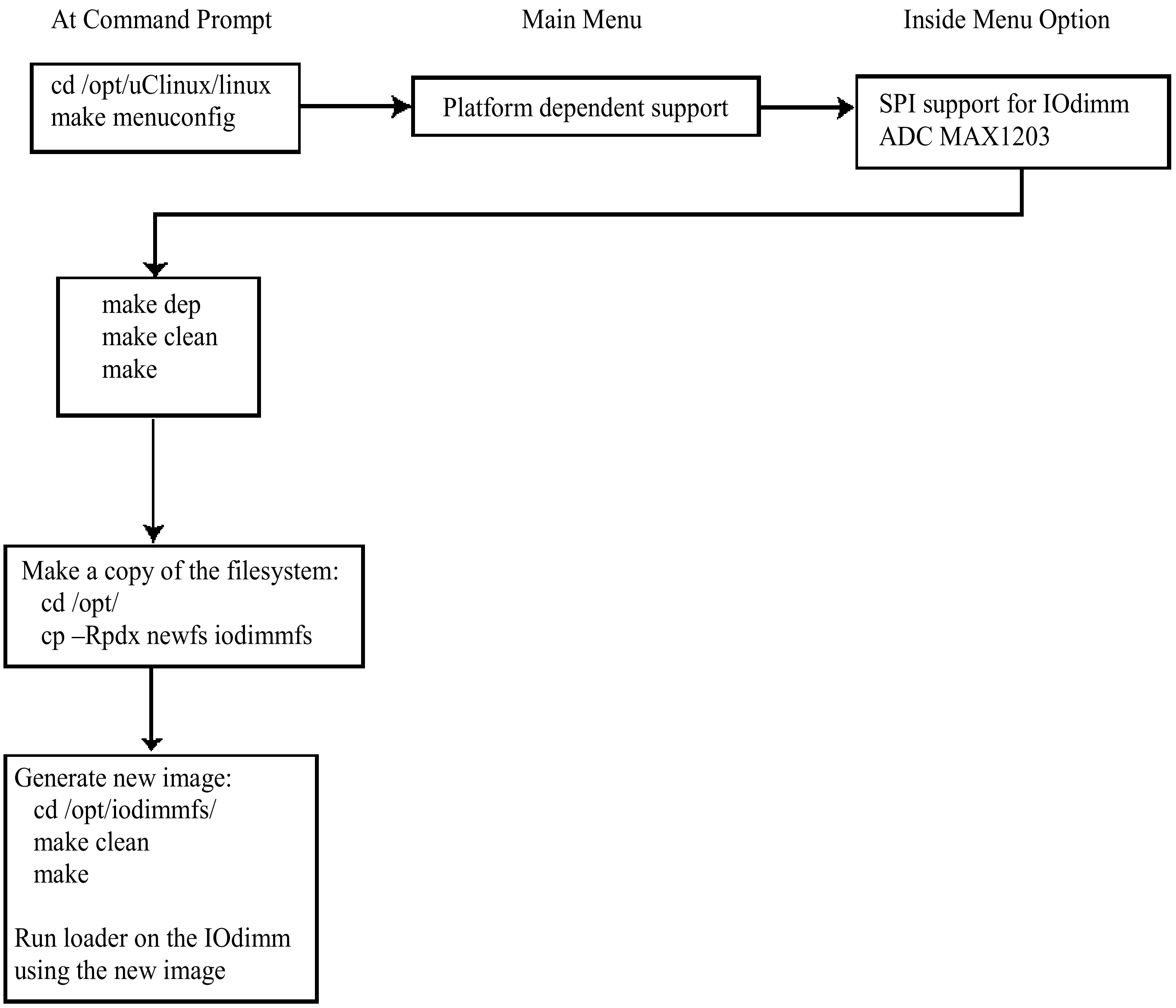
```
      cd /opt/
      cp –Rpdx newfs iodimmmfs
```

Then create a combined image of the new kernel and filesystem.

```
      cd /opt/iodimmfs
      make clean
      make
```

Finally use **imagez.bin** and run **loader** on the IOdimm to write in the filesystem and kernel.  Please refer to the User’s Manual for details on running **loader**.  The IOdimm is now configured for its I/O operations.

## Kernel and Filesystem Configuration Flow Chart



## Available I/O Pins

The IOdimm has 8 analog inputs, 2 analog outputs, 8 digital inputs, and 4 digital outputs available for use. Note that only the analog I/O channels lead to headers on the backplane. Any digital I/O channels must be accessed by soldering wires to the peripheral slot where the IOdimm is inserted.

*Table 1: List of all available I/O pins*

| Category | Channel | Backplane System Slot | Backplane Header Pin |
|---|---|---|---|
| Analog Input | 0 | A1 | JP1/1 |
| | 1 | B1 | JP2/1 |
| | 2 | A2 | JP1/2 |
| | 3 | B2 | JP2/2 |
| | 4 | A5 | JP1/5 |
| | 5 | B5 | JP2/5 |
| | 6 | A7 | JP1/7 |
| | 7 | B7 | JP2/7 |
| Analog Output | 0 | A9 | JP1/9 |
| | 1 | B9 | JP2/9 |
| Digital Input | 0 | A15 | JP1/15 |
| | 1 | B15 | JP2/15 |
| | 2 | A16 | JP1/16 |
| | 3 | B16 | JP2/16 |
| | 4 | A17 | JP1/17 |
| | 5 | B17 | JP2/17 |
| | 6 | A18 | JP1/18 |
| | 7 | B18 | JP2/18 |
| Digital Output | 0 | A19 | |
| | 1 | B19 | |
| | 2 | A20 | |
| | 3 | B20 | |

## I/O Functions

The low level functions used to manipulate the I/O channels are the system calls `open`, `lseek`, `read`, `write`, `close`, and `ioctl`. The I/O channels are accessed through 3 character drivers for the digital I/O, ADC, and DAC. The uses of these functions are demonstrated in the sample programs **fir.c**, **xor_iodimm.c**, and **even_parity_iodimm.c**.

*Digital Inputs and Outputs*

For the digital input and output pins, each channel corresponds to one byte, where channel 0 is the 0th byte, channel 1 is the 1st byte, etc. The device can be accessed by a handle to the node `/dev/io0` for both read and write. When writing to the pin, 0 will be low (0V) and non-0 will be high (as shipped, 12V, or if strapped, $V_{IO}$). When reading a pin, the driver will read back 0 for a low signal, and 255 for a high signal. `lseek` should be used to position the file pointer for access to I/O channels. There are 8 digital inputs and 4 digital outputs, so channels [0-3] can be written to and read from, but channels [4-7] can only be read.

Specific to the digital outputs, there are `ioctl` calls to pass control information to the device driver. Each `ioctl` call takes three parameters, the handle, a descriptor of the desired command, and an integer, though in some cases the integer is ignored.

```
result=ioctl(handle, PIC_SETUP0, PIC_SETUP_PUSH_PULL)
```

Each of the command descriptors are listed below. If any of them are unsuccessful executing the function, an error will return. Please note that the PWM channels are currently not supported. Both PWM0 and PWM1 cannot be used at the same time since PWM0 is connected to the low-side driver and PWM1 is connected to the high-side driver.

`DAC_POWER_DOWN` should be used to power down the DAC once it is no longer needed. Note that the argument is ignored for this `ioctl` call.

`PIC_SETUP0`, `PIC_SETUP1`, `PIC_SETUP2`, `PIC_SETUP3` will configure each digital out channel according to the integer specified in the argument. Each of the argument values are described below.

- `PIC_SETUP_LO_SIDE` will configure an output pin as a low-side driver.
- `PIC_SETUP_HI_SIDE` will configure an output pin as a high-side driver.
- `PIC_SETUP_PUSH_PULL` will configure an output pin as a push-pull output.
- `PIC_SETUP_HI_Z` will configure an output pin into a high impedance state.

*Analog I/O*

For both the ADC and the DAC, each channel corresponds to 2 bytes, such that channel 0 is the 0th and 1st bytes, channel 1 is the 2nd and 3rd bytes, etc. The data in the bytes is binary encoded, in little endian format where the least significant bit is at the lower offset in the file. Values that can be written or read from the channels are unipolar from 0 to 4095, corresponding to 0 to 4.095V, thus there is 1mV per count. `lseek` should be used to move around the file to access I/O channels. For both reads and writes, as few as 1 or as many as all analog I/O channels can be accessed at once.

As shipped, each ADC channel has a divide by 4 attenuator stage and a multiply by 2 amplifier stage. Thus for a signal applied to analog input pins on the backplane, a count of 4095 will correspond to a voltage of 8.192V.

For the DAC, analog output 0 has a multiply by 2 gain stage, so a count of 4095 corresponds to a voltage of 8.192V. Analog output 1 has a 4-20 current output circuit, with a count of 0 corresponding to approximately 3.5mA and 4095 corresponding to about 25mA.

## Sample Programs

The sample program **fir.c** demonstrates the use of the ADC and DAC of the IOdimm. The digital I/O functions are demonstrated by the sample programs **xor_iodimm.c** and **even_parity_iodimm.c**.

**fir.c** will read analog input from a channel on the ADC. This input will be fed into a FIR filter, and then the output is written to the DAC. The source code for **fir.c** is available in `/opt/samples/card_specific/iodimm/fir`.

There are 29 coefficients *h(k)* used to calculate the digital output values, *y(n)*, given the digitised input *x(n)* using the summation

$$y(n) = \sum_{k=0}^{28} h(k) * x(n-k)$$

The filter is prototyped using a Hamming window given N=29, the finite impulse response given by:

$$h(n) = \frac{\sin(0.33\pi(n-14))}{\pi(n-14)} * \left(0.54 - 0.46\cos\left(2\pi\frac{n}{28}\right)\right)$$

Note that:

$$\lim_{x\to 0}\frac{\sin(kx)}{x} \approx k$$

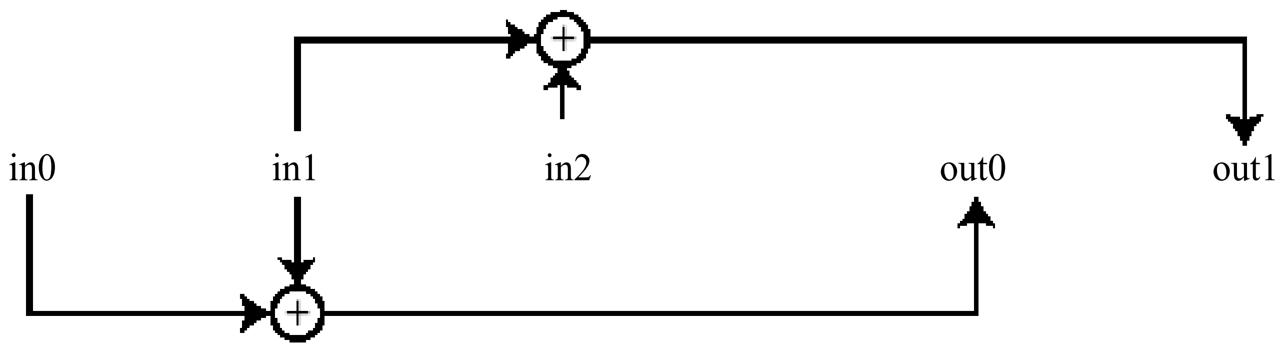
as shown by the Taylor expansion of sine

$$\sin(x) \approx x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \text{K}$$

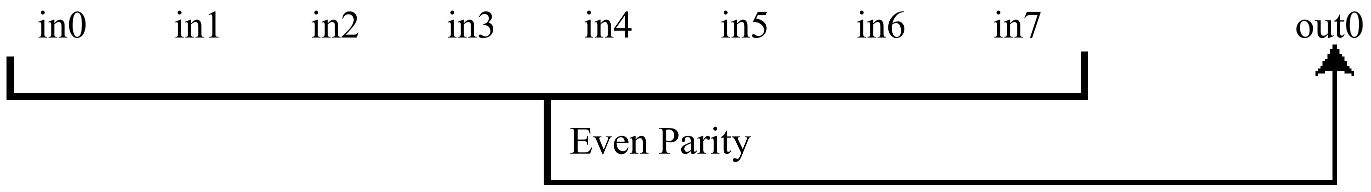
$$\frac{\sin(kx)}{x} \approx \frac{kx}{x} - \frac{(kx)^3}{x*3!} + \frac{(kx)^5}{x*5!} - \frac{(kx)^7}{x*7!} + \text{K}$$

The sample FIR is a quick and dirty low pass filter with linear phase. The design parameters of the filter are a –3dB cutoff at $\Omega_c = 30\pi$ rad/sec, $\omega_c = 0.3\pi$ rad and an attenuation of 50dB at $\Omega_r = 45\pi$ rad/sec, $\omega_r = 0.45\pi$ rad. For example, a sampling rate of 64000 samples/second ($T^{-1} = 64000$ samples/s), yields a analog frequency cutoff of 9.6kHz and the 50dB attenuation corner point at 14.4kHz.

**xor_iodimm.c** performs the XOR logic function on 3 inputs. The XOR is performed on the first two inputs and the result output to the first output. The result of the second and third input XOR are sent to the second output. The source code for **xor_iodimm.c** is available in `/opt/samples/card_specific/iodimm/dio`.



**even_parity_iodimm.c** is a program that will do even parity on 8 input pins, and the result is sent to 1 output pin. Thus, if there is an even number of '1' inputs, then the output will be '0'. Conversely, if there is an odd number of '1' inputs, the output will be '1'. The source code for **xor_iodimm.c** is available in `/opt/samples/card_specific/iodimm/dio`.



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# D5 Oops Documentation

## Using Oops

June 11, 2003 Version 0.1

Authors: Bernice Lau, Robert Austen

## Introduction

**oops** is a program to upload/download to a M68K family processor using EMU mode.

The executable must be compiled for the first time using gcc on the development platform. There is a **Makefile** included in

```
/opt/boottools/oops/src
```

Prior to running ‘oops’ the jumper must be inserted on EMU BREAK and the dimmPCI board reset. Any terminal software (minicom, etc.) that may be using the serial port must be closed. **oops** can be invoked from the directory **/opt/boottools/oops** using

```
./oops
```

After ‘oops’ has finished running, the jumper on EMU BREAK must be removed and then the dimmPCI board resets to boot a new kernel.

## Purpose & basic format of files for oops

**init.b** contains the initialisation sequence for the Dragonball VZ. The file is a Motorola b-record for the processor, and **init.b** is the default initialisation file. It is the first file to be transferred using oops. (See the appendix for more information on **init.b**)

**xloader.bin** is a binary file that is the default upload program file. This program will write and verify the flash. It is the second file to be transferred. Once it has been sent, it will start running and will participate in receiving the target image.

**loader.bin** is a binary file that will also write and verify the flash. This program will not start until the target image has been loaded into RAM.

**kernel.bin** is a binary file containing the image of the compiled dimmPCI kernel, and it is the default kernel file. **kernel.bin** is in the current working directory, but it is a symbolic link to a stable kernel image with a descriptive but lengthy file name.

**image.bin** is a binary file set as the default download program file, which will make an image of an area of the Dragonball memory, most likely flash.

**memory.bin** is a binary file to download an image of the memory.

## Upload & Flash

There are two mode types in which ‘oops’ can operate in order to upload & flash an image.

Type 1
- sends init.b
- sends flash programmer type 1 (loader.bin)
- sends image (in b-record format)
- run flash programmer
- capture output

Type 2 (default)
- sends init.b
- sends flash programmer type 2 (xloader.bin)
- runs flash programmer
- sends image (in binary format)
- captures output

In Type 2, the image is sent in binary using **xloader.bin** to receive 4K blocks at a time, which is faster. With Type 1, the image must first be converted to b-records prior to sending. The mode of upload & flash can be changed as follows:

```
-lp or -up  <flash programmer type 1>
-xp         <flash programmer type 2>
```

If **oops** is run without arguments, then it will run by default in Type 2 mode.

To specify the image to be uploaded:

```
-k <image>
```

The default image file to be uploaded is **kernel.bin**.

Prior to writing to the flash, the flash memory will be erased. There are two different methods of erasing.

| | |
|---|---|
| `-ec` | erases the entire flash before writing (default) |
| `-em` | erases the flash as required in ’64K blocks’ |

Erasing the flash with the `-em` option allows for the journaling flash file system (jffs) to be preserved when you wish to load a new image consisting of the kernel and root filesystem.

```
| kernel | rootfilesystem |   <blank>  |     jffs      |
<—— replaced ——>                    <—saved—>
```

After the image has been written to flash, the system will reset. There are two reset modes:

| | |
|---|---|
| auto-reset (default): | `-ra` |
| manual reset, waits for user input: | `-rm` |

## Upload & Run

**oops** will follow the following process to upload & run:

send init.b
send program
start program
capture output

To specify the image to be uploaded:

```
-k <image>
```

This will load the image at the start of flash, address 0.

To start a kernel, or other object, already in flash:

```
-sk <absolute start address>
```

For upload & run, if both `-k` and `-sk` are used in conjunction, an object can be downloaded to location 0 and start execution at an arbitrary location. For example, a kernel could be compiled to run in RAM, loaded and then run.

## Download

**oops** will follow the following process to download:

send init.b
send program
start program
capture output

Most often, the capture file option will be used in this process.

To download using the default download program, **image.bin**:

```
        -d
```

This will download an image from the flash.

To specify the download program:

```
        -dp <download program>
```

Two binaries have been provided for this purpose, **image.bin** and **memory.bin**. **image.bin** as mentioned above is the default, while **memory.bin** will download an image of the memory.

The start and length of the image desired for download can be specified:

```
        -dr <start, length>
```

eg. If you have 1Mbyte flash, and you wish to download 4 sectors of the jffs, then the start address and length would be specified by:

```
            -dr 0xC0000 0x40000
```

The start address specified here is relative to the start of the flash.

The addressing mode can also be changed with the following options:

relative to flash, start is 0x0 (default mode): `-df`

absolute addresses: `-da`

After obtaining the captured output, it can be fed into the **conv** utility to convert the output file to binary. The source code for the utility is located in **/opt/boottools/oops/src/conv**.

## Common oops program arguments

Verbose output mode: `-v`

Quiet operation mode (default): `-q`

To select a serial port (default is '/dev/ttyS0'): `-p <serialPortName>`

Change to fast serial port, 230.4kbps (default is 115kbps): `-pf`

Select initialisation program file(default is init.b): `-ip <initFilename>`

Select a capture output file: `-c <captureFilename>`

By default, there is no capture file specified, and all information will go to standard output. When capturing the output, if the file already exists, then the new information will be appended to the end of the file, not erase the current contents.

## Appendix

The following is the format of the **init.b** file:

aaaaaaaaccdd'\n\r'

where

| | |
|---|---|
| aaaaaaaa | address |
| cc | count (cannot be equal to 0) |
| dd | <cc> number of bytes |
| | eg. cc=2, there must be dddd = 2 dd |
| '\n\r' | each line is followed by a carriage return and/or line feed |
| WAIT <n> | causes a wait for <n> ms |
| # ——— | comment |

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# E Appendix

## Licensing, Copyrights & Liability

### dimmPCI$^{TM}$ Software Development Kit Distribution

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#### Preamble

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# F Appendix

## References/ Suggested Reading

1998 O’Reilly. Linux Device Drivers.  Alessandro Rubini.
2001 O’Reilly. Understanding the Linux Kernel. Daniel P. Bovet & Marco Cesati.